CONSTRUCTION TECHNOLOGY TRANSFER
FOR CONSTRUCTION WORKS IN ETHIOPIA:
THE CASES OF GRADE ONE GENERAL CONTRACTORS

YESHIALEM ZELALEM MULU

MASTER OF SCIENCE

ADDIS ABABA SCIENCE AND TECHNOLOGY UNIVERSITY

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By

YESHIALEM ZELALEM MULU

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Declaration

I hereby declare that this thesis entitled "**Construction Technology Transfer for Construction Works in Ethiopia: The Cases of Grade One General Contractors"** was composed by myself, with the guidance of my advisor, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted, in whole or in part, for any other degree or processional qualification.

Name:	Signature	Date
Yeshialem Zelalem Mulu	-----------------	**....................**

Certification

This is to certify that the thesis prepared by **Yeshialem Zelalem** entitled with ‘‘**Construction technology transfer for construction works in Ethiopia: The cases of grade one general contractors** ’’ has been approved by the following examiners after the presentation of the thesis for the Masters of Science in Civil Engineering, Construction Technology and Management.
Date of Defense 25/10/18

Principal Advisor

Wubishet Jekale (PHD)	______________	______________
	Signature	Date

Member of the Examining Board:

1.	____________________	_____________	_______________
	External examiner	Signature	Date
2.	____________________	_____________	_______________
	Internal examiner	Signature	Date
3.	____________________	_______________	______________
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4.	____________________	_______________	______________
		Signature	Date
5.	____________________	_______________	______________
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Abstract

International technology transfer from developed to developing countries carry on stimulating rapid industrialization and economic growth globally, particularly in the fast growing newly industrialized countries like Ethiopia. The technology transfer has been one of the popular methods to improve the efficiency and productivity in the construction industry. The main objective of this study is to investigate the construction technology transfer practices and development of technological capabilities of the Ethiopian Constructions Industries. A cross-sectional descriptive research design was used on 48 grade one general contractors. Structured questionnaire, case study and key informant interview inquiries were used to collect the primary source of the data. The data were entered, manipulated, organized and analyzed using Statistical Package for Social Science software (version 24). Both descriptive and inferential statistics were used to analysis the data. To determine the important factors which are capable to affect the applicability of the construction technology transfer selection criteria, multiple linear regression model was used. Moreover, the result of the study reveals that 5 predictor variables under examined, only 4 variables of them: new technology, transfer process, technology transfer channel and creating conducive environment significantly affect the appropriateness of technology transfer selection criteria with 95% confidence interval. The model for Ethiopian construction work is developed based on the findings of the regression model. As the result illustrated that the local construction firms in Ethiopia are characterized by mostly small and the lack of capacity and capability, delivering project on time, cost and expected quality. Furthermore, the level of technology transfer practice in the construction industry is very low and fragmented. From the total of grade one general contractor there is also a big technology practice gap among the industries. In addition, the formulated model uses as a guide to facilitate the technology transfer process for the construction industry.

Key works: Transfer process, technology transfer channel, construction technology transfer practices

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List of Acronyms

ASEAN	Association of Southeast Asian Nations
CED	Cost Efficient Design
CM	Construction management
CSCBP	Construction Sector Capacity Building Program
CT	Construction Technology
CTT	Construction Technology Transfer
DB	Design Build
BCBLTE	Bicultural, Bilingual and Technology Expert
BOT	Build Operate Transfer
DTT	Dual Technology Transfer
ESCBP	Engineering Sector Capacity Building Program
FDI	Foreign Direct Investment
GPR	Ground Penetrating Radar
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
GTPII	second Growth and Transformation Plan
HRD	Human Resource Development
ICT	Information Communication Technology
ILO	International Labor Organization
ICTSD	International Center for Trade and Sustainable Development
JV	Joint Venture
KII	Key Informant Interview
KTI	Knowledge and Technology Integrators
LDC	Less Develop Country
MNC	Multinational Companies
MoCB	Ministry of Capacity Building
MoE	Ministry of Education
MoC	Ministry of Construction
ND	Note Dated

NIS	National Innovation System
NGO	None Governmental Organization
PBC	Performance based contracting
PPP	Public Private Partnership
SME	Small and Medium-Sized Enterprises
SPSS	Statistical Package for Social Science
STI	Science, Technology and Innovation Policy
TBM	Tunnel Boring Machine
TT	Technology Transfer
TVET	Technical and Vocational Education and Training
UCBP	University Capacity Building Program
UKCES	United Kingdom Commission for Employment and Skills
USA	United States of America
UNIDO	United Nations Industrial Development Origination
UNCTAD	United Nations Conference on Trade and Development organization
VA	Value Added
3D	Three Dimensional

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Technology Transfer (TT) can be defined as the shared responsibility between the sources and the destination for ensuring that technology is accepted and at least understood by someone with the knowledge and resources to apply and use the technology (Waroonkun *et al*., 2005). Technology can be transferred from one place to another, from one organization to another organization, from a university to an organization, from one country to another etc. (Wahab, 2012). Regarding to this study, technology transfer implies as when all types of knowledge relating to the construction field such as design, research, the transferee construction firms and the transferor foreign or domestic firms are working with the Ethiopian construction industries. As expected, the transferor firms would have origins either in developed nations, developing countries or the firms found in the countries to each other's.

However, many developing countries due to the lack of technology and the 'know-how' for managing large, sophisticated, multi-disciplinary construction projects and, therefore, the skill from developed countries will undoubtedly continue to be in demand. The construction industries within developing countries like Ethiopia do not have the necessary expertise and finance to undertake more complex projects such as road and complex skyscraper buildings etc. (Waroonkun, 2007). These deficiencies are overcome by implementing international TT initiatives on construction projects in developing countries to enhance the local industry's technical capabilities. In these days, many construction firms in developing countries stand to gain the advantage of international TT from many developed countries in terms of skills, knowledge of construction and information technology, knowledge management, technical capabilities, etc. Such kinds of technology transfer capable to enhance the growth of local construction industries and help to scale up the construction infrastructure into international construction standards (Waroonkun, 2007).

Several criticisms were, and are, leveled against this form of technology transfer, because the technologies are often restricted to particular sectors, techniques or aspects, and are seldom up-to-date, are transferred on unfavorable terms including, for instance, prohibition of the export of the goods produced, and are often inappropriate to the host countries, being capital intensive, import dependent, high energy consuming and polluting; licensing fees also tend to be high. The technologies tend to lead to the decay of indigenous and traditional technologies (Wahab, 2012). However, over the past few years, technology transfer through direct foreign aid has been increased. Studies by UNCTAD (1990) show that despite policy changes and liberalization of investment control regimes in many developing countries, foreign direct investment in these countries actually diminished during the eighties. Thus, as most of the literatures brand technology transfer as a myth, and consider the international firms as using access to key technologies and innovative capacities as instruments of domination.

Now a day's building construction industries are boosting globally and consuming huge amounts of resources. Construction Technology Transfer (CTT) facilitates the growth of construction sector. Responsibly managing CTT on a building infrastructure construction project is a vital component of increasing the efficiency of productivity.

1.2. Statement of the Problem

The construction industry in developing countries is faced by many challenges impeding its development (ILO, 1987). Wells (1984) reckons that the problems confronting the construction industry in developing countries are limited local production of building materials, poor quality of locally produced materials, heavy reliance on imports, high and rising prices of building materials, lack of skilled labor, and low involvement of local contractors. Moreover, construction technology transfer problem delayed the industry to travel as like as the developed nation do. Bringing the technology alone did not do any; it should support by man power development and ways of the model how it transfers and implement in the country have to under consider. For Ethiopia construction industry there is no enough study which focuses on the CTT model.

According to UNIDO, 1980 and UNCTAD, 1990, technological weakness of construction industry in developing country like Ethiopia is attributable to:

- Low level of accumulation of technology; limited capacity to import technologies owing to a weak foreign exchange earning capacity and inability to attract foreign investment
- Tendency to adopt import-intensive models of industrialization making industry unable to stimulate the development of local technologies.
- Failure to consider science and technology as integral parts of national development plans, and to adopt, implement and monitor relevant policies.
- Insufficient investment in science and technology owing to economic limitations and a relatively undeveloped private sector.
- Inability to select and manage suitable technologies owing to shortage of technology personnel due to inadequate educational and training facilities, insufficient attention to the orientation of educational traditions and curricula to technology.
- Insufficient institutional infrastructure non-existent, inadequate or poorly coordinate government agencies for promoting and/ or supporting private sector initiatives, weak or non-existent research and development institutions, poor linkages between them and industry, and inadequate dissemination and application of their results.
- Inadequate physical infrastructure and information necessary for investments in technology; social structures and culture not supportive of technology for example, absence of "social carriers" or "champions" of technology development; and lack of mechanisms to facilitate the transfer of technologies.

There are numerous forms of channels or modes of TT which takes place in the public and private sectors. Some of the channels are considered to be very effective, such as training programs, managerial and institutional programs, procurement and contractual contracts; whereas, the others are regarded as less effective for instance licensing agreement (Ming and Xing, 1999). Therefore, to select the better technology transfer channels of the technology should be under considered. But, in the developing countries like Ethiopia there was limited study related to the TT channel, TT process and the applicability of construction technology model especially in the construction industry.

Furthermore, it is known that most of the CTT approach in Ethiopian construction industry is practiced in a fragmented manner. There is a variability of the technology usage between the contractors and consultant in construction. The technology transfer plays a great role in the country development and productivity of the project. In construction projects delay, wastage, quality problems and lack of productivity are the issues of the construction companies faces now a day (Wubishet Jekale, 2017). The challenges in construction comes from each trade of work in the project development which starts from conception up to Rehabilitation/Demolition needs different types of technology and knowledge. So, constructing a model would lead to guide what kinds of transfer procedures the construction industry utilizes to reduce excess wastage and improve the quality and productivity of the industry.

1.3.Research Objective

1.3.1. General objective

The main objective of this study is to investigate the construction technology transfer practices and development of technological capabilities of the Ethiopian constructions industry.

1.3.2. Specific objectives

- To assess the existing construction technology transfer practices of the Ethiopian construction industry;
- To identify type of construction technology and CTT mode applicable for the Ethiopia construction industry;
- To develop construction technology transfer model for the Ethiopian construction industry.

1.4. Research Questions

1. What are the existing construction technology transfer practices in the Ethiopian construction industry?
2. What types of construction technology and construction technology transferring mode is applicable in the Ethiopian construction industry?
3. What kinds of model should be advised for the Ethiopian construction industry?

1.5. Scope and limitation of the study

The overall goal of this study is investigating construction technology transfer and development of technological capabilities based on productivity enhancement, cost minimization, time saving and delivering good quality production in the context of Ethiopia construction environment. Therefore, the scope of the research is delimited to grade one General contractor because they are qualified to undertake a variety of construction works such as building, road, bridges, dams, railways etc. works of unlimited contract value. Moreover, even if technology is defined as a process, method or input, due to budget constraint, the study only focus on the method and process of technology transfer.

The study may be more important if it was included all level of contractors those found in Ethiopia. But, it is too difficult to analyze, organize, and interpret the data within the given time interval. So, the study should be confined into the grade one general contractor rather the entire contractors.

As the study is cross-sectional in design, the possibility of recall biases resulting in under or over reporting and misreporting of events was likely. In addition, most of the information was questionnaire-based; so, questions that required a good memory were vulnerable to recall bias.

Moreover, in spite of the researcher's efforts to gather the necessary information as objective as possible, the analysis of this study was based on the opinion of respondents, so the respondent may not cooperate well to fill and gave all the necessary data. This may in turn limit the ability to make broader generalization from the study undergone.

1.6.Significance of the Study

The study provides contractor strategies for justifying construction technology transfer; thereby enhancing technology efficient project delivery. It would be helpful in increasing productivity, minimizing cost, time effective and better quality on the construction industry.

Moreover, the study is important because it provides information on how construction technology transfer model help the construction industry of the country. It will also offer some possible solutions on problems related to the previous trained of practice of construction industry. And it is expected that the industry will take necessary measures to overcome problems regarding the construction technology transfer in improving quality of CTT model based on the recommendations that will be forwarded by the other researcher. Likewise, the study will add to the existing literatures and may serve as additional source for reference and it will also serve as a spring board for other researchers who want to conduct detailed research on the issue.

1.7. Definition of Terms

Appropriate / Intermediate Technology: Is a technology that will increase productivity at lower costs (compared to advance technology), use local resources, skills, and easy to operate, maintain etc. (Wubishet Jekale, 2017).

Construction: - is the Development of Physical Infrastructures (Buildings (Housing, Social, Commercial and Industrial), Transport (Highway, Railway, Waterway, and Airway), Water Works (Supply and Sewerage, Irrigation, and Hydro Power) and Other Civil Works (Wubishet Jekale, 2017).

Construction Industry: - defined as a system which includes, contractors and others engaged in assembly, engineers and design professionals, manufacturers of components, materials and equipment, developers, and those who regulate the industry, as well as the people or the corporations that own or use the final product (Boyd *et al,* 1975).

Technology: - According to the Encyclopedia Britannica 15th edition Technology may be defined as the systematic study of techniques for making and doing things better. It is also defined as either a method or an input to the development of product(s) or execution of service(s) or work(s) that improves efficiency, strength, safety and eases of doing them, and decreases none or less value adding activities or processes and adverse impact to the Environment (Wubishet, 2017).

Construction Technology: - According to Wubishet (2017) Construction Technology is either a Construction method or an input associated with the development processes of Physical Infrastructures that improves efficiency, strength, safety and ease of executing them, and decreasing none or less value adding activities or processes and adverse effect on the Environment.

Technology Transfer: - May also be applied to the process by which a technology developed for a specific use or sector becomes applicable in a different productive setting. Transfer of technology may refer to a process that takes place within or across national boundaries, and on a commercial or noncommercial (concessionary) basis. It may refer to the physical movement of assets or to immaterial elements such as know-how and technical information, or most often to both material and immaterial elements. Transfer of technology may be linked to the movement of physical persons or more specifically to the movement of a specific set of capabilities (Al-Khazarji, 2013).

Construction Technology Transfer:- The process of sharing the knowledge of construction industry by all means from one region/country to another, such as project management skills, building procedures, construction materials, equipment, software and general construction skills for under staff (Al-Khazarji,2013).

Knowledge and Technology Integrators (KTI):- People or professionals who have left their home country to live abroad and who are qualified to work in developed countries (Diasporas) and their familiarity with the languages and cultures of both transferor and transferee allow them to blend in with both foreign and local staff for technology transfer (Al-Khazarji, 2013).

Knowledge Gap: - This is a disparity that may occur between developed countries (transferor) and developing ones (transferee) due to the scientific, technical and managerial differences between them. For instance, a managerial, technical and scientific construction-related gap occurred between both public and private local companies in Iraq, and Finnish companies (Al-Khazarji, 2013).

Local/Indigenous Technology: Is the local tacit knowledge matured over long standing wisdom traditions & practices that is unique to a given culture or society finds application in tools, techniques, inputs, processes and methods. It is a technology that will enable to focus inward & look for comparative and competitive advantages globally than relying on catching up at the frontiers of the existing technology worldwide. (Wubishet Jekale, 2017).

Foreign Technology: is the technology it doesn't develop indigenous technological capabilities (https://link.springer.com>chapter).

Mechanism: - The technology transfer mechanism has been defined as any specific form of interaction between two or more social entities when the technology is transferred and used to describe popular business arrangements that are deployed to transfer technology (Ramanathan, 2000; Radosevic, 1999).

Channel:-technology transfer channel is the link between two or more social entities in which various technology transfer mechanisms can be activated (Radosevic, 1999).

Transfer Mode: The means or vehicle, whereby knowledge or technology can be transferred (Al-Khazarji, 2013). The term "mode" is used to refer to the transfer links between the phases of the technology development chains of the transferor and transferee (Ramanathan, 2000).

1.8.Organization of the Research

This study organized with five chapters. The first chapter describes the background of the study, the research problem, research question, objectives, and significance of the study, delimitation and limitation of the study, definition of terms and organization of the study. Chapter two reviews the literature which leads to the development of conceptual framework. Chapter three is discussed about the method of the study. Sources of data and variables narrated in this part. Methods of data analysis are also described in this chapter. Whereas, chapter four discuss on the results and analysis followed by, conclusions and recommendations, and suggestions for further study in chapter five.

CHAPTER TWO

2. LITERATURE REVIEW

Introduction

This chapter deals with theoretical parts and empirical reviews of the related studies on the construction technology transfer practices and development of technological capabilities of the constructions industry. Definition of the concepts by different authors, aims and context of the construction technology, relationship between modes of technology transfer on the success of TT selection criteria. Furthermore, conceptual framework of the study is presented.

2.1.Construction technology

The growth of new technologies in the Construction Industry is expected have an impact on the way construction is performed in the future. With any new methodologies, there are expected to be changes in the composition of the workforce. New construction technologies may require the attainment of new skills or trades with the consequence of establishing new or redesigned training programs. All of these impacts are expected to require new training methodologies and/or associated up-skilling of the workforce (construction training fund, 2014). In the table below the new technology are categorized in to ten categories. These are earth work, floor, walls and slab works, Temporary structure (formworks), Reinforcement works, concrete works, block masonry works, finishing works, water proofing works, information and communication technology and alternative delivery system. The identified technologies are applicable to improve quality and productivity, minimize cost, minimize time of project completing, and improve safety performance in the field of construction industry.

Table 2.1 Construction technology

Technology	Type	Description	Source and demonstration (Citation)
Earth Work	Spider excavators	A very modern and high-tech excavation equipment. It can be used in every imaginable terrain.	https://www.youtube.com/watch?v=j87k71kOBis
	Mini excavators	It is highly applicable for tight and confined areas)	video]https://www.youtube.com/watch?v=UF9mfxGaN-w
	Articulated hauler	It is a very large heavy duty type of dump truck used to transport loads over rough terrain.	https://www.youtube.com/watch?v=sMymKTI3KT8
	Tunnel boring machine(TBM)	It uses to excavate circular tunnels. It used in variety of spoil/rock strata causes minimal strata disturbances.	Christian *et al*, (ND)
Floors Walls and Slabs	Pre-fabricated and assembly system	Manufactured off-site in factory/workshops, out of inclement weather, and delivered to site on semi-trailers.	Tido Kutuba, (2016)
	Pre-cast system (Manufactured off- site)	From aggressive ground conditions or possession time constraints to limited on-site storage or aesthetically demanding finishes, precast concrete elements provide economic and durable solutions	Tido Kutuba,(2016)
	Bubble Deck slab flooring	Pre-constructed concrete flooring system with bubble spheres throughout, therefore reducing the weight of the slab used for multi-story structures and amount of material.1 kg of plastic replaces more than 100 kg of concrete	Shivani et al, (2017
	EzyProfile-slab profiling tool	For easy slab set up, new re-usable tool to replace traditional profiling system on a building site.	https://ezyprofile.com.au
	Self-cleaning glass windows	The self-cleaning property of self- Clean glass is made possible by a durable, transparent coating of titanium dioxide (TiO_2) applied during the manufacturing process.	Krister, (2012)
Temporary structure (formwork)	Steel panel modular formwork	This consist of panels fabricated out of thin steel plates stiffened along the edges by small steel angles. The panel units can be held together through the use of suitable clamps or bolts and nuts. The panels can be fabricated in large number in any desired modular shape or size. Steel forms are largely used in large projects or in situation where large number reuses of the shuttering is possible. This type of shuttering is considered most suitable for circular or curved structures.	https://www.youtube.com/watch?v=I8G1YKvh-Rk
	Aluminum formwork system	used for both high rise and low rise buildings	www.grandedificedevelopers.in, accessed in 2018
	Plastic formwork systems	It is easy transportation and speedy assembly of components reusable	Abhishek, 2017
	Movable formwork	Advantages of organic restressing application in structures with high “live load /dead load” ratios and	Pacheco et al, (ND)

		with relatively “slow” loadings, such as movable scaffolding systems used for bridge construction	
Reinforcement	Mesh bending and cutting machine	It is automatically accomplished the functions of rebar’s feeding, straighten, bending and cutting.	video]https://www.youtube.com/watch?v=e3wiFrmNxg4
	Rebar processing	Automatically accomplish the functions of rebar’s feeding, straighten, bending and cutting. Continuously bend various stirrup of plane figure. High efficiency and accurate Processing precision	[video]https://www.youtube.com/watch?v=qlH-2eJgQCQ
	Reinforcement bar coupler	It allowing a safe, reliable and efficient method of providing continuity of reinforcement through stop ends and element intersections.	www.sdgconstructiontechnology.com
	Automatic rebar tying machine	It is a compact and easy to use tool. The innovative, automatic hammer action eliminates the swinging motion required to drive nails and the potential for 'miss hits'.	Albers et at, (ND)
Concrete works	Concrete pumps	It is more efficient way of pouring concrete, using a machine to transfer liquid concrete. It delivers concrete in continuous stream and pump can move concrete both vertically and horizontally Concrete pumping is a more efficient way of pouring concrete, using a machine to transfer liquid concrete. There are two basic types of pumps that are used, one is known as a ‘boom pump’ and the other is commonly called a ‘line pump’.	www.concretconstruction.net, (accessed 2018) [video]https://www.youtube.com/watch?v=Puxt1c7GoDs
	Cast- in- place Booms	Stationary Placement Booms it is used for easy to transport and set up. Short set-up times. Grows upwards with the structure and Small space requirement With or without counterweight	https://www.youtube.com/watch?v=ueAJx1jITBQ
	Fiber reinforced concrete (FRC)	FRC, failure takes place due to fiber pull-out or de-bonding. Unlike plain concrete, FRC can sustain load after initial cracking	http://www.scirp.org/journal/ojce, http://dx.doi.org/10.4236/ojce.2015.52018, (accessed in 2018)
	Admixture chemicals	Chemicals added to concrete to impart a specific quality to either the plastic (fresh) mix or the hardened concrete. Admixtures are classified by the following chemical and functional physical characteristics: air entertainers, water reducers, retarders, hydration controller admixtures, accelerators, specialty admixtures and supplementary cementations materials	https://www.researchgate.net
	Automatic Concrete screening machine	The automatic screening machine can make the activity faster and hence making it cheaper.	
Block masonry	Movable/stationary block making machine	It gives high end Production, high quality products Precision	https://www.youtube.com/watch?v=qSmYypKRy9c
	Mobile mortar mixer with a Tele- handler		

Finishing Works	Plastering machine	The machine works with conventional cement mortar which brings it to a smooth, flat finish with variable and adjustable thickness to suit each application. It makes rendering easier, faster, and effortless as compare to manual application this time and money saving machine, keeps up with the ever changing world of building automation	Arivazhagan, (2014)
	Glass Tiles	It is a manufactured piece of hard-wearing glass generally used for covering floors, walls, and shower. Some uses of glass tiles are look beautiful, easy to clean and environmentally friendly	www.custombuildingproducts.com, (accessed 2018) https://www.youtube.com/watch?v=fYA4JOU_Ljo
	Airless spray painting machine	This will impact on the plastering trade as dry wall on brick process is used overseas as alternative to hard wall plastering. Some up-skilling may be required.	https:thespruce.com/paint-spray
Water proofing materials	Masonry water proofer	controls water migration through concrete masonry and brick walls	Construction Training Fund, (2014
	Damp proofing cream	Waterproof layer that is applied into the base of a wall to prevent the absorption of ground water into the home. Beautifies and controls water migration through concrete, masonry, brick and stucco walls.	https://www.permagard.co.uk/cream, (accessed 2018) Duleeka, (2015).
Information and communication technology	3D hand held computers	Intuitive and able to scan spaces/rooms for placement of pipes etc. Already used for off-site manufacture of stone/granite worktops.	Construction Training Fund, (2014)
	3D Printing	Additive manufacturing or 3D printing is a process of making three dimensional solid objects from a digital model. The process uses additive processes where an object is created by laying down successive layers of material. 3D printing is considered distinct from traditional machining techniques (subtractive processes) which mostly rely on the removal of material by drilling and cutting	Construction Training Fund, (2014)
	Building Information Modeling (BIM)	It is an IT package facilitating management of, and collaboration within, the construction process	Construction Training Fund, (2014)
	Ground Penetrating Radar (GPR) systems for civil works	GPR is a geophysical method that uses radar pulses to image the subsurface and detects reflected signals from subsurface structures. Is used in a variety of materials, e.g. soil, rock, ice etc. and can detect objects and material changes	Construction Training Fund, (2014)
	Spectra precision laser Scanning	Construction positioning technology to help precisely control tasks like long-range high-accuracy elevation control and fine grading for major projects.	Construction Training Fund, (2014)
	e-business technology (for procurement)	e-business technology that has the capability to enhance inter and intra organization communications, thus, eliminating problems connected to communication among key project partners	Adzoe and Ingirige, (2014)
Project	Design build	These form of project delivery system is a system of	Mekonnen Asaminew,

delivery system	(DB) Delivery system	contracting whereby one entity performs both design/engineering and construction under one single contract.	(2013)
	Construction management (CM) Related Delivery system	The owner contracts separately, but somewhat simultaneously, with a design consultant and with a firm whose primary expertise is construction. The different type of construction management delivery system are CM as Agent/ free, CM at Risk and CM Prime contracting	Lema Mosissa, 2006)
	Public Private Partnership (PPP) Delivery system	Public Private Partnership (PPP) Delivery system: It has developed in part due to financial shortages in the public sector. PPPs have demonstrated the ability to tie together additional financial resources and operating efficiencies inherent to the private sector. The different categories of PPP are Build operate and Transfer (BOT),Performance based contracting (PBC) which is used to obtain better performance or lower costs or both and the basic concept of PBC is to adopt contracting specifications and procedures permitting the contractor to devise the most efficient and effective way to perform the work	(Lema Mosissa, 2006) John, (1998)

2.2. Technology transfer

There are many dimensions used to classify technology transfer the criteria are vertical and horizontal, commercial and non-commercial, direct and indirect, formal and informal.

Basically, international technology transfer distinguished into: material transfer such as the transfer of material, final products, components, equipment, and turnkey plant; design transfer basically involves the movement of designs, blueprints and the know-how to manufacture previously designed products or equipment and capacity transfer provision of the knowhow and software not simply to manufacture existing products but more importantly to innovate and adapt existing technologies and products and ultimately design new products (Saad, 2002).

Another classification of TT made by Andrezej (2005), distinguishes into vertical transfer which is the transfer of technical information within stages of a particular innovative process from basic research to applied research, from applied research to development, from development to production and horizontal transfer which occurs when technology transfer is used in one place, organization or context and transferred and used in another place.

In other direction TT can be classed into direct and indirect. Direct transfer used when the transferee is in a direct contact with the transferor of technology. It includes direct contacting of individual experts and consultant companies in engineering design and plant construction enterprises, training, technical information and equipment purchased directly from manufactures. Whereas, indirect technology transfer occurs when a company in developing country plays an intermarry role in packaging the technology for the developing country. It tends to be adopted where a country lacks the capacity to undertake direct purchase (Stewart, 1979).

Furthermore, the study made by UNCTAD (1987) classifies TT as commercial and non-commercial. Commercial transfer involves payment of a direct and indirect price for technology and it includes foreign direct investment, joint ventures, licensing, franchising, marketing contracts, technical service contracts, turnkey contracts and international subcontracting. In other hand noncommercial international technology transfer include the review of technical journals and the training of foreign student exchange of scientists and engineer co-operative research and development.

2.3. Technology Transfer Mode

The technology transfer mode is principally a type of contractual agreement agreed by both parties of transferor and transferee.

2.3.1. Technology transfer actors

The main actors who participates in the transfer of technologies are governments, sponsors or financiers, sector's or industry's administrators, implementers; transferee such as individuals and organizations, established and emerging companies and transferee employees like management and workers; transferor as like individuals, organizations and countries and transferor experts; Universities, research and development institutions, societies, NGOs and their experts; partners, subsidiary, agent, subcontractor; developers, suppliers, disseminators; and public, special interest groups **(**Wubishet Jekale, 2017**).**

2.3.2. Technology Transfer Process Stage

Souder (1990) develop a model which uses as good guide for selecting strategies or polices for the adopting the technology. The model consists of four technology transfer stages as listed below:

1. Prospecting stage: amid at screening alternative technologies and selecting the technology which fits on the context of the country;
2. Developing stage: contain physical and research and development activities concerned on enhancing elaborating embodying and tailoring the selected technology to meet the requirement;
3. Trail stage: in this stage the selected technology and developed are tested on the field to check its applicability;
4. Adoption stage: it is the final development, technology modification and user's implementation activities.

Adikibi (1984) develop a model called technology acquisition model for systematic analysis of the process of foreign technology transfer based on four process stages. This process carries the following technology transfer strategies:

i. Physical transfer stage: concerned with the actual movement of technology elements such as plants, machinery, equipment, plants, and personnel from the transferor to transferee country. The stage covers up to structure of production is set up to commence operation. The duration depends upon the level of development of both transferor and transferee.

ii. Anchorage stage: is critical in the acquisition of foreign technology and it has three phases. The prime once is low level of technology anchorage and the dominance of foreign input are noticed. The preparation of detailed training program and the provision of the training facilities take place in this phase of anchorage process. The next process is characterized by domestic factor dominance, training of the local employees. Longest in duration and difficult to accomplish. While the last phase is all the expected evidence of complete anchorage of technology appears, like effective control in management, production, technical and financial functions. This phase is shorter in duration than the primary and secondary phases and the technology is matured for diffusion to the industry.

iii. Diffusion stage: The emergence of imitator indigenous firms within the industry. And this manifests in three ways this are imitative, production development of indigenous enterprises and increased number of host country nationals knowledgeable in the technology. The start and completion time of the diffusion stage depends more on environment in the host/transferee national than foreign environment.

iv. Assimilation stage: concerned on high degree of concentration on research and development and deeper understanding of the process technology in order to determine whether to adopt or modify the technology to fulfill local need. No completion time in this stage because adoption and modification of now-how is continuous process.

2.3.3. Technology Transfer barrier

This part commences with a brief presentation of common technology transfer problems faced by SMEs. This will be followed by the "Life Cycle Approach for Planning and Implementing a Technology Transfer Project." (Saad, 2000)

2.3.3.1.Technology Transfer Process Issues

1. Problems during the technology justification and selection stage: The issues came during technology justification and selection stage are wrong selection of technology based on misjudgments when preparing a business case for a TT project, the cost of buying, installing, operating, and maintaining the technology is too high, the technology selected is too complex for easy understanding and assimilation of the transferee, the technology needs considerable adaptation to suit local conditions and obsolescence of technology while the transfer is in progress.

2. Problems during the planning stage: some of the problems faced during planning stage are transferor (seller) underestimates the problems in transferring the technology to a developing country setting, transferor does not fully understand transferee needs, transferee managers are not involved in the planning which is carried out only by the transferor, too much attention is paid to the hardware to be purchased and not enough attention is paid to skills and information acquisition, overestimation of the technological capabilities of the transferee by the transferor thereby leading to unrealistic expectations on how well the transferee can meet target dates, poor market demand forecasting by the transferee of the outputs to be produced by using the transferred technology, the objectives of the transferor and transferee are not compatible and mechanisms chosen for implementing the transfer are not appropriate.

3. Problems during negotiations: some of the problems faced during negotiation are differences in negotiation approaches and strategies, lack of trust between the transferor and transferee, goal incompatibility during negotiations, inability to reach agreements on pricing, product, and marketing strategies and both parties try to achieve results in an unrealistically short period of time.

4. Problems during technology transfer implementation: the following problems arise in the implementation phase of technology transfer shortage of experienced technology transfer managers, lack of trust in transferor developed systems by the transferee, inability to achieve quality targets, delay in obtaining supplementary materials, needed for quick implementation, from the local environment, high cost and poor quality of locally available materials needed to implement the technology transferred, inadequate tracking of the technology during implementation, cost overrun due to poor implementation.

2.3.3.2. Corporate Capability Issues

Corporate capability problems during technology transfer categorized in to first problems due to inadequate skills, such as, inability of the transferee to attract the required skills due to financial and industrial restrictions, lack of experience of the transferee’s workforce and absence of required skills at the industry level, lack of training of transferee personnel , absence of incentive systems at the transferee firm for learning and assimilating new technologies and language barriers that inhibit effective communication between transferor and transferee personnel and restrict effective transmission and assimilation of relevant information. Second problems due to inefficient management like lack of visible and committed top management support for the project, lack of top management guidance to decide the type of the technology to be acquired, remuneration, incentives associated with the transfer, and the control of the flow of information, differences in working methods and practices between the transferor and transferee managers, individual or organizational competition for the ownership of the technologies and the presence of the "not-invented-here" syndrome and Failure of top management to identify transferee and transferor personnel who would work closely starts form project initiation through full implementation.

2.3.3.3. Operating Environment And National Innovation System (Nis) Issues

The problems came during technology transfer on operation and national innovation systems are shrinking of local markets due to adverse changes in the economic levels of the country, poor physical infrastructure, inadequate supportive institutional infrastructure to provide support in terms of finance, information, skill development, and technology brokering, inadequate mechanisms for intellectual property protection, lack of local suppliers who can deliver quality supplies and lack of policies to develop such suppliers, high dependency on foreign suppliers and imports, lack of good education and training institutions to upgrade skills, ineffective legislation and incentives such as tax holidays, tariff adjustments, and industry parks to promote technology transfer, bureaucratic delays at various levels of government in obtaining approvals and clearances for finalizing technology transfer agreements, ineffective and sometimes excessive government intervention and regulation, foreign exchange restrictions, inability of new ventures to compete with former monopolies, often owned by government and uncertain tax environments.

2.3.4. Technology Transfer Channels/Mechanisms

There are several methods of classifying technology transfer channel based on different criteria. One of the basic types of classification is domestic and international transfer.

Domestic transfer process is basically involves the flow of technology from one stage of research and development process to another. When the new context or stage in which the technology is to be applied is significantly different from the original one, it is required to adapt the technology. In essence it is the movement of technology along the continuum from basic research to the innovative product where by an adaptation process refines the technology with each transfer stage (Yared Lemma, 2011).

International technology transfer has also different channels to transfer to the transferee country for the purpose of meeting socioeconomic and political development of the country. The main channels are formal or commercial-mediated channels and informal or non-commercial-mediated channels (UNCTAD, 1987).

2.3.4.1.**Formal or commercial-mediated channels**

Technology transfer channel is the link between two or more social entities in which various technology transfer mechanisms can be activated (Radosevic, 1999).This technology transfer channels can be accompanied by various forms, such as:

1. Foreign direct investment

Foreign direct investments (FDI) are made outside the country of transferor but inside the investing company. It includes all flows either direct or affiliates, reinvested earnings and net borrowing equity capital from the investor. It also consists of a package of assets and intermediate products, capital technology management skills access to markets and entrepreneurship (Radosevic, 1999).

This investment is made in the form of holds wholly owned enterprises, of the capital that is generally entirely owned by investors of a country or region, foreign investment shares; foreign ownership buys the stock and achieves a certain proportion of some or all of their control; investment and joint venture organized in the host country; and investors reinvest their profits (Sifeng, et al., 2010; Hotelman, et al., 2004 as cited by Yared Lemma 2011).

2. Joint Ventures (JV)

It is collaboration or new investment involving shared ownership between local firms in host/transferee country and its transferor/foreign partners (Adeoba A., 1990). It is a business association between two or more parties who agree to share the provision of equity capital investment, control and decision making authority and profits or other benefits of the operation (Ozal, 1991). It is important to the introducing new technologies and diffuse them because transferor try to follow quickly the success of fellow-companies in the same industry and to introduce similar technologies into new joint venture, learning technical now-how and obtaining necessary resources from the parent companies (Chatterj, 1990).

Joint venture can be classified into equity joint venture: assets rights and liabilities are shared with partners; and non-equity joint venture: co-operation between partners is established on a contractual basis (UNCTAD, 1988).

In fact joint venture is advantageous for a significant change in industry and in competitive behavior, to create new firm strengths, to share in the use of technologies which couldn't afford to explore alone, create lower operating costs, product lives are shorter, domestic firms becoming global competitors and good in the development of new industries (Harrgan K.R., 1988).

3. Licensing Agreement

Licensing is the sale of manufacturing technology by multinational companies or licensor to a non-controlled entity located outside the home country of the multinational company or licensee. Licensing agreement is a legal contract under which the licensor confers certain rights such as permission to use individual property rights with patents, trade mark, brand names and copy rights, upon the licensee for a specified duration in return for certain payments, royalties. Licensing agreement doesn't include sharing of equity by the firms involved.

Licensee can access the available technology at the time of signing the agreement. And also the licensee and licensor agree that the available technology will be developed in a specific product area before transferring it to the licensee (Killing, 1980).

4. **Imports of capital goods and machinery**

Imports of capital goods provide another way of acquiring the means of production without the transactional costs involved in foreign direct investment or technical licensing agreements. The import of capital goods and machinery is modes of embedded technology transfer for building infrastructure and strengthening the transferee technological capability. They introduce into the production processes new machinery, other capital equipment and components that incorporate technologies that do not necessarily incorporate high or frontier technologies, but are nevertheless new to the recipient firm. Imported capital goods can prove a cheap way to develop local technological capabilities if they can be used as models for reverse engineering to produce the machines locally (Wie Thee kian, 2005).

5. **Turnkey plants**

A turnkey contract which is the contractor of a firm undertakes the responsibility for carrying out all the technical and managerial operations and activities needed for the planning construction and installation of a technical project before submission to local ownership and exchange for a fee. Turnkey agreements provide for the complete physical package of technology from one party to another. Less developed countries use turnkey plant for the early stage of their industrialization (UNCTAD, 1973).

6. **Management Contract**

This contract is an arrangement under which operational control of an enterprise is vested by contract in a separate enterprise and performs managerial functions for fee like production management, personnel management, procurement of goods and services and marketing. The advantage of management contracts are substantial amount of organizational skills can be transmitted to transferee by personnel training programs or by working together with transferor, have access to high experts of transferor personnel, research and development actives and other sources of suppler, diverge objectives of the parties regarding the operation and duration of the project (Yousef, 1988).

7. The Franchising Agreement

Franchise is a particular form of licensing agreement between the franchiser and franchisee. Basically, the franchiser provides rights, such as use of trade mark, brand name, services of technical assistance, training, merchandising an management in return of fee. Less developing country governments prefer the management contract mode when the franchisers are foreign firm because the institutional structures are not adequate enough to protect franchising (UNDO, 1979).

8. Cross-border movement of personnel

Another significant channel of international technology transfer is cross-border movement of technical and managerial personnel. Indeed, many technologies cannot be effectively or affordably transferred without the complementary services and know-how of engineers and technicians that must be on-site for some period of time. An important advantage of MNEs is the ability to shift such skilled personnel among subsidiaries as needed. Markets for temporary movement of skilled workers among unrelated firms may be more restrictive and less flexible, raising the costs of such transfer and absorption (Maskus *et al*, 2003).

2.3.4.2.Informal or non-commercial-mediated channels

i. International Subcontracting (Outsourcing)

Subcontracting is informal channel of TT which contracting partially contributes to carrying out a major contract. The essential characteristics of subcontracting are the coupling of export and technology, function as training school where knowledge transfer through production specification and requirements (Radosevic, 1999).

ii. Imitation/ Reverse Engineering

The most significant non-market channel is the process of imitation, in which a rival firm learns the technological or design secrets of another firm's formula or products. It may be achieved through product inspection, reverse engineering, de-compilation of software, and even simple trial and error. Whether imitation is legal or illegal depends on the scope of intellectual property protection and the security of trade secrets from unfair competition. What distinguishes it from the earlier channels is that imitation bears no compensation to the technology owner in formal markets. As such, it seems an attractive form of learning and diffusion from the standpoint of developing economies. However, imitation may be a costly process and tends to divert attention from local innovation, so, a full accounting of its impacts is more complex (Maskus *et al*, 2004 as cited by Yared Lemma 2011).

iii. Departure of employees

Departure of employee helps for the transfer of one firm's technologies has been entrusted leave the firm and join or start a competitor firm based on that knowledge. Such competition can be a significant form of information diffusion in industries and locations where cross-fertilization of knowledge is important and employees are traveling. Again, the technology is transferred without formal compensation to the original (Maskus *et al*, 2004).

iv. Temporary migration

Technology to be transferred through the temporary migration of students, scientists, and managerial and technical personnel to universities, laboratories, and conferences located mainly in the developed economies. Note that in-depth training in science and engineering may be gained this way, suggesting that it is a particularly long lasting form of TT. The challenge for developing countries in this context is to encourage its expatriate students and professionals to return home and undertake local scientific, educational, and business development (Hoekman M, 2004).

2.3.5. Technology Transfer Model

This study described construction technology transfer model developed in several countries (Malaysia China Thailand, China, Africa, Taiwan, and Ethiopia). The models were developed by doing empirical studies. On the empirical the concept behind the findings are discussed in detail in the empirical review section.

The empirical review is focused on studies conducted by carful observations and scientific based research. It is a way of gaining knowledge by means of direct and indirect observation or experience. Empirical evidence can be analyzed quantitatively or qualitatively. Some of the empirical studies made in technology transfer are discussed below:

1. Comparative Marketing TT/ Calantone *et al*., (1990) model

The technology transfer made by Calantone *et al***.,** (1990) presents a system made up of five elements that describes the process and describe the relationship between the element and the factors that influence. Those five basic elements are:

- Environment:-the elements in the environment include prior experience of technology transferor and transferee, cultural factors, economic factors and political factors.
- Actors: - they include technology transferor and transferee and international organization also government and nongovernmental organizations (NGO).

- Structure: - describes the relationships and interaction mechanism between the actors involved with the TT process. The information communication channel between them is affected by political, economic, and business relationships between them.
- Process: - focused on the actual negotiations between the technology transferee and transferor. The negotiation is impacted by channel and selection of technology, partner and mode of transfer from the perspective of both transferees and transferors.
- Functions: - concerned with the implementation of a conceived international TT project. This includes evaluation and control of implementation and also feedback on the success of the implementation.

This study adds value by introducing the concept that international TT is a dynamic iterative process and the five element system is effective in describing the general contracts that make up the international TT phenomenon.

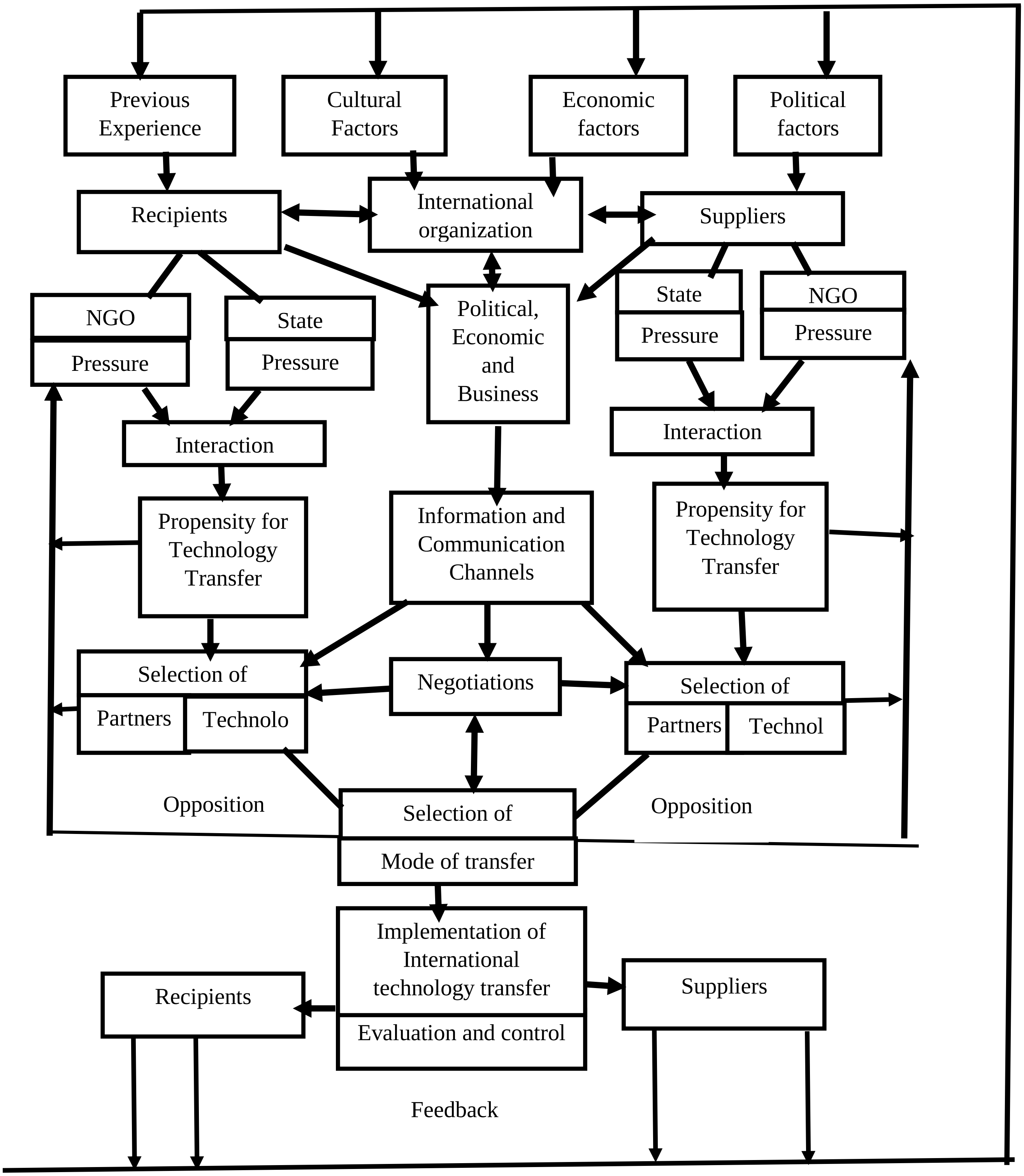

Fig 2.1: Comparative Marketing TT Model

2. Technology Acquisition / Process Model Simkoko (1992) model

The Simkoko (1992) research finding was focused on TT in the construction industry of developing countries in 12 Countries (Africa, South America & Asia). The study was examined the impact of TT program and other internal and external environmental factors on construction project performance. The study investigates the effect of organizational form, the management team and construction technologies on the involvement of local firms. The seven sets of variables that identified by Simkoko model are discussed below:

- Project delivery system: consists of organization methods used and overall project execution which is the alternative delivery system like Design bid build (DBB) , Design build (DB), Build operate transfer (BOT)
- Project management team: focused on the degree of integration of local and foreign project managers. It needs willingness and active participation of the parties.
- Transfer programs:-focused with training costs and time, involvement of local contractors, employment of technical staff and supervision management. It concerns on deliverable and plan.
- Client characteristics: are special requirements of clients, personal characteristics of the client, financial status, degree of involvement in project decision making and objectives.
- Project characteristics: focused on project size, complexity, schedule, cost, risks and uncertainties.
- Design and construction technologies: concerned with construction methods, materials, equipment, resources, management techniques and past performance of construction technology.
- Project performance: focused on competence development of local firms and was measured by the degree of involvement and impact on local employment.

In the Simkoko study the statistical analysis of results involved chi-squared tests and ranked correlation coefficients. The model has given some ideas on enabling and outcome factors to be used for the conceptual model for international TT for the construction projects. The study focused on competence development of local firms than the entire value added from TT process.

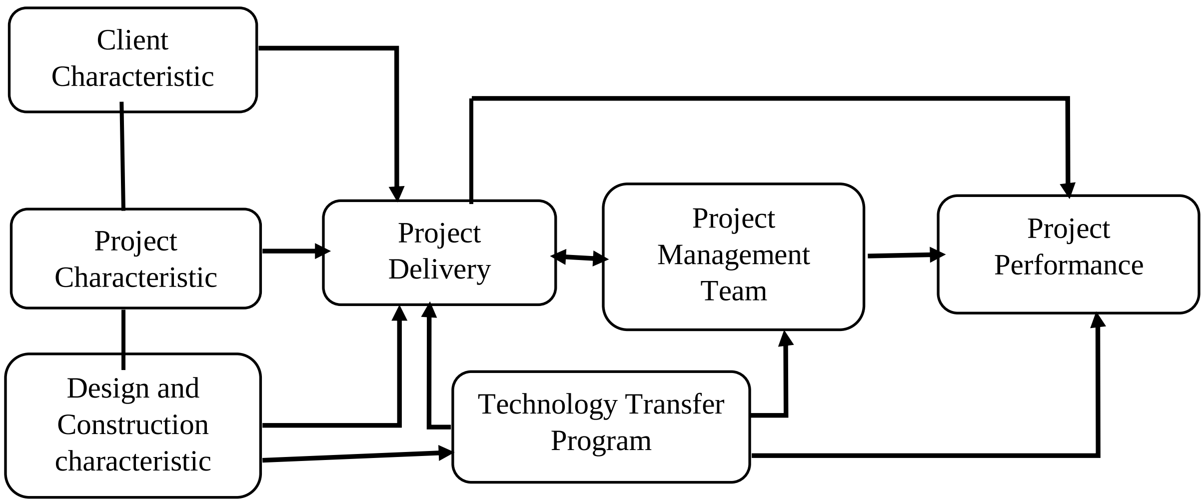

Fig 2.2: Technology Acquisition / Process Model

3. Transferor-Transferee for Technology Transfer/ Lin and Berg (2001) model

The Lin and Berg (2001) research was followed an exploratory study system on the effect of cultural difference on TT projects and it was provided empirical evidence that confirms the previous conceptual models in the field of TT. The study focused on TT project on which the Taiwanese manufacturing companies. Their research was also identified three groups of factors:

Nature of technology: concerned with complexity (how complex the technology and how easily it can be learnt), maturity (how long the technology has been developed and used prior to its transfer) and codification (how well the technology is documented and recorded).

Previous international experience: focused on the level of international experience of the technology transferee and transferor.

Cultural difference: it is the difference between the technology transferee and transferor.
Technology transfer effectiveness: this factor was focused on measuring final technical performance and comparing it to four technical benchmarks.

- Technical performance transferor: how much the transferee has learnt

- Whether the transferee achieves technical performance as planned as the beginning of the TT project.
- Technical performance of competitors
- Technical performance on similar projects

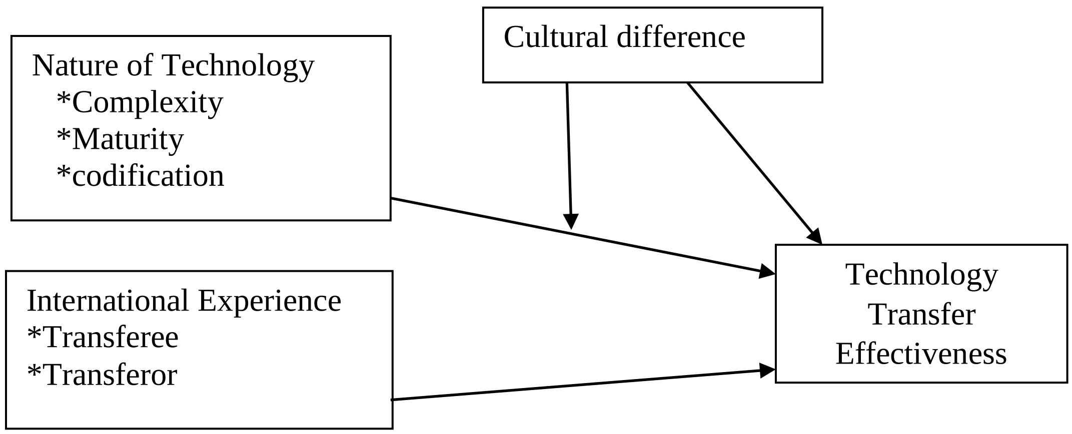

Fig 2.3: Transferor-Transferee for Technology Transfer Mode

4. **TT Life Cycle based intra-firm/ Milik (2002) model**

The Milik (2002) model is presented as an interactive broadcasting TT model for intra firm technology transfer in Malaysia. The study comes from the review of existing conceptual literature in the TT field. The data collection for the research was semi structured interview with management personnel, review of archival records and observation to factories undertaken to achieve unbiased data range. This research identified TT as the most knowledge intensive and problematic relationships within a firm. This model is specific to manufacturing companies; the factors identified are applied to all TT processes within multinational companies. The basic concept discussed by Malik (2002) is listed below:

- Factors likely to help: includes adequate resources, market pull, communication skill, familiarity, willingness, culture of trust, motivation.

- Factors likely to inhibit: includes no interest, no market perceived benefit, lack of trust, no incentives, language barriers, technology complexity and no training.
- Transmitter and Receiver: describes the ability of both parties to transmit and receive the technology and the intent to use it.
- Mode of transfer: actual process used to communicate the knowledge between the two parties. The mode of transfer focused on contract types used to transfer the knowledge and also makes distinction between the transfer of tactic and explicit knowledge.
- Feedback mode: is concerned with the long term management practice that is essential for the success of international TT.

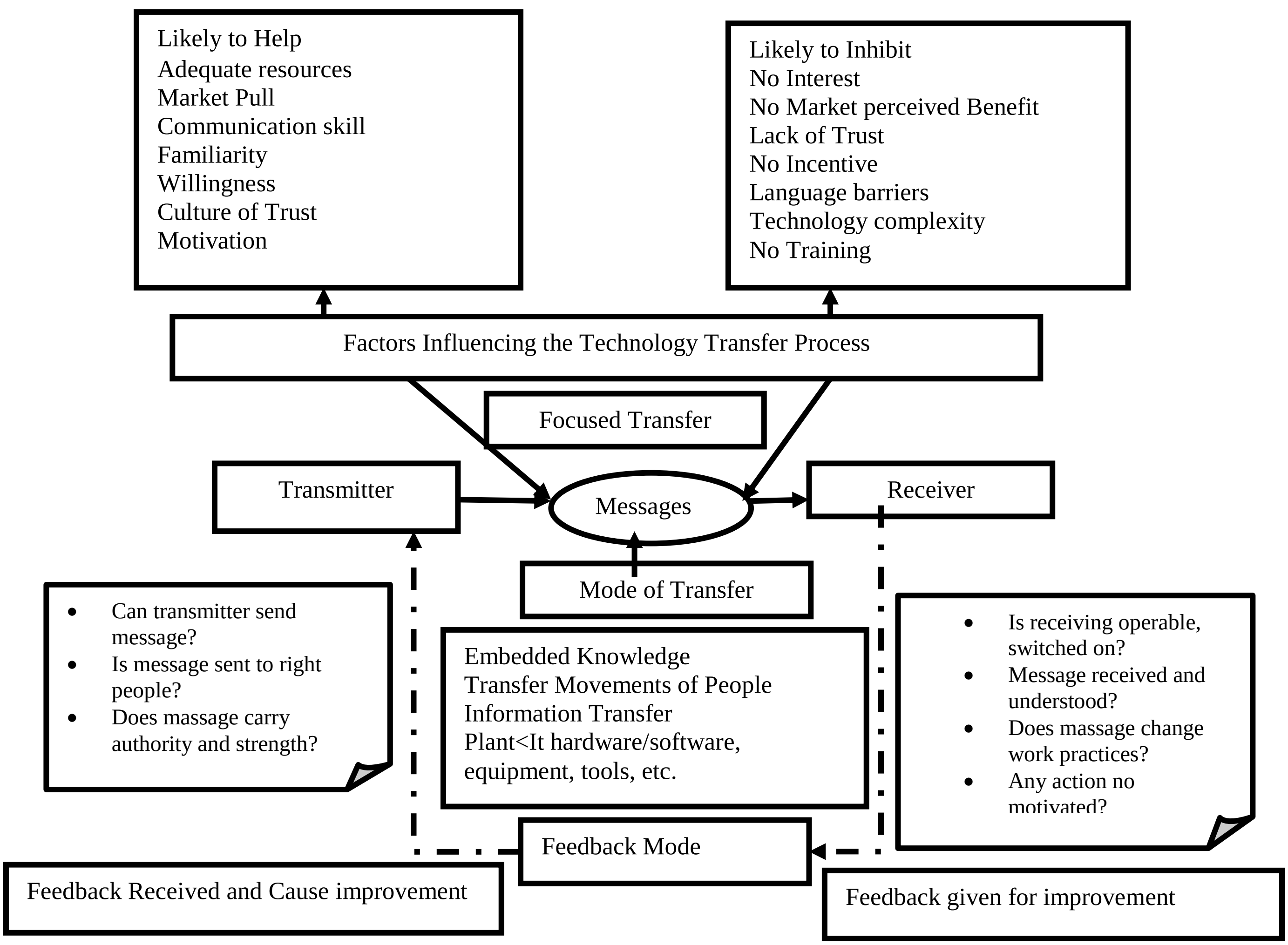

Fig 2.4: TT Life Cycle based intra-firm Model

5. Source to Destination Movement based CTT/Wang *et al.* (2004) model

The other TT model considered in here is that the model developed by Wang *et al.* (2004). Their study focused on the transfer of knowledge from a multinational company to a subsidiary. The model was developed reviewing archives and publications and from semi-structure interview with 62 multinational companies in China. The study made a distinction between tacit, knowledge that is non-modifiable and is deeply rooted in action, procedures, routines, commitment, ideas, values, and emotions, and explicit, knowledge that can be codified and expressed in the form of data, technical specifications, manuals, universal principals, patents. The model developed in this study identified two stages in the transfer process.

- First stage is focused on parent's contribution of knowledge and the factors affecting the extent of knowledge such as parent's capacity to transfer which is the firm specific knowledge and the ability to import that knowledge in a firm and assimilated by the recipient. And parent willingness to transfer the extent to which knowledge to be contributed and affected by the importance of the subsidiary and the ownership type.
- Second stage focused on the subsidiary's acquisition of knowledge which is affected by the factors like subsidiary's capacity to learn concerned on the qualification of its employees and the emphasis on training. And subsidiary's intent to learn concerned with the intent of the employees and the link between learning and reward.

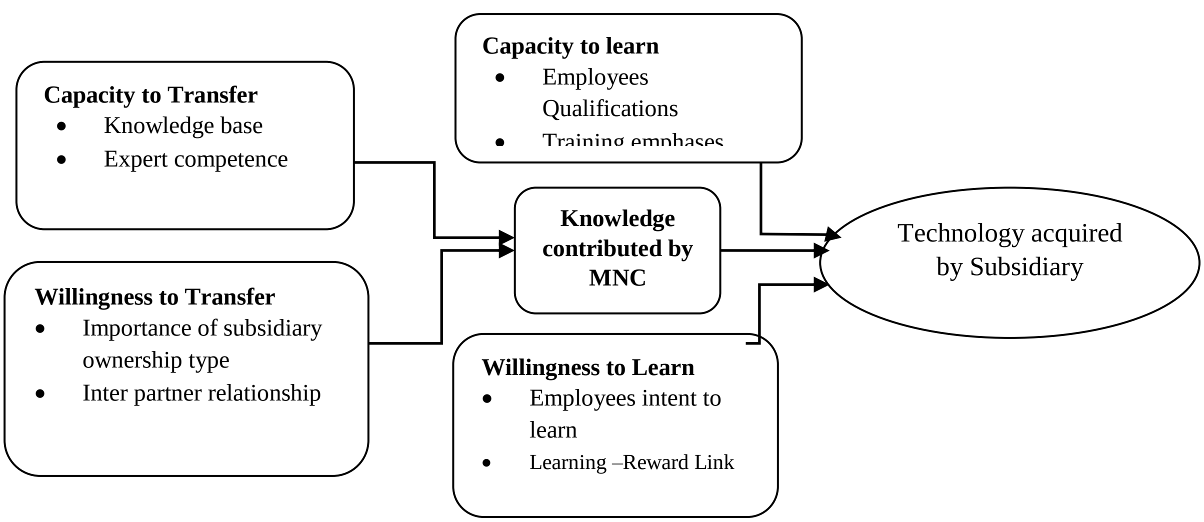

Fig 2.5: Source to Destination Movement based CTT model

6. Value Added TT /Warookun (2007) model

The other research was done by Warookun (2007) international TT model from developed to developing country for Thailand construction industry. The study was developed by reviewing related researches, questionnaire surveys, pilot study and primary study and follow up case studies. It has considered five components which are discussed below:

- Transfer Environment: focused on complexity level, mode of transfer, government policy, government enforcement, etc.
- Relationship Building/learning Environment: concerned with culture, trust, understanding, communication, teamwork, training, local sub-contractors, supervisors.
- Transferor Characteristics: concerned with willingness to implement, degree of experience, transferor management, knowledge base
- Transferee characteristics: focused on willingness to learn, degree of experience, transferee management, knowledge base
- TT Value Added: concerned with economic advancement (competitiveness, performance), Knowledge advancement (improved knowledge, improved working practices, long-term adaptation), project performance (financial performance, schedule performance, quality standards).

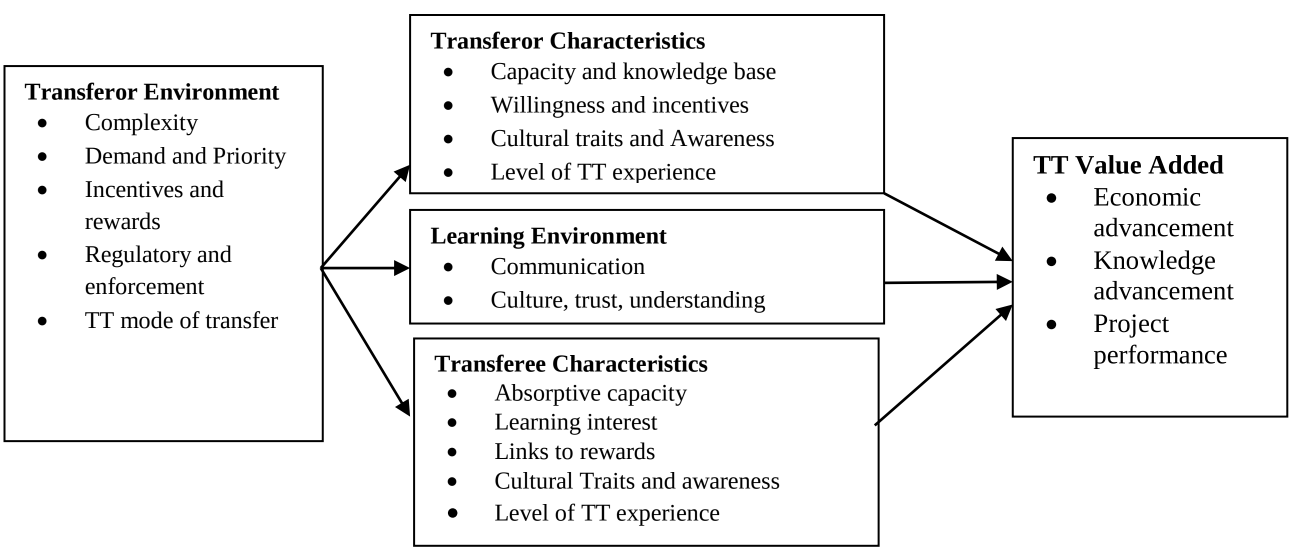

Fig 2.6: Value Added TT Model

7. **Needs and Technology Assessment Kebede and Mudler (2008) model**

The model considered by Kebede and Mudler (2008) discussed crucial steps and factors in technology transfer. This model defines nine TT process stages which are discussed below:

1) Needs Assessment (problem identification): This is the first step in the technology transfer process. Needs have to be identified, and the basic characteristics of the needs in terms of quantity, price levels, and cultural preconditions. This involves identifying the needs of the receiving society. Basically the society is the center of analysis, not the available technologies.
2) Analyze how to satisfy the needs (options identification): The needs identified require options to meet them. These options of how to satisfy the needs may not necessarily be technology related.
3) Analyze the (national) strategy and the policy plans for fulfilling the needs and for the options to satisfy that needs: In general developing nations have set their priorities by strategic plans or development plans. These plans might determine the resources that governments are willing to commit to the options.
4) Make or Transfer decision: Even though most of the technologies of developing countries are transferred from overseas, there are technologies that can be developed and used locally. The "make option" is attractive if the resources and skills needed to produce it are locally available, and the technology is of great economic or strategic interest to the country, but investing in the "make option" only for reasons of strategic interest can lead to disaster.
5) Technology assessment: assess the technology considering social, cultural, economic and environmental factors:
6) Decision on a technology: After assessing the possible alternative technologies, the most appropriate technology is selected. If no satisfactory technology is available, the strategic plans and policies should be reconsidered.
7) Physical Transferring process: This is the actual and material transferring process of the selected technology. It includes all the procurement and transportation processes of the

technology. But, it must be remembered that technology transfer does not necessarily mean physical technology transfer, as services can also be included.

8) Implementation: The final process of the technology transfer is implementing the technology. Additional recommendations for developing countries as stated by Awny (2005) are worth to be mentioned here; absorption and further modification of the technology should be taken into account. Proper consideration should be given to personnel training and maintenance.
9) Measuring the success: Once the whole transfer process is done, measuring the success or failure of the transfer process helps to learn from mistakes and leads to improving the next transfer processes.

In the study of Kebede and Mudler (2008) the factors that should be considered in assessing the technology from the developing countries perspective are discussed in depth. The factors are categorized in to four groups.

The first technology assessment factor is a technical factor which contains physical facilities such as infrastructures and support technologies, services and systems like maintenance and operation. The second technology assessment factors is economic factors that includes Human resources, capital, land, other raw materials, macroeconomic condition, Market and property right. The third factor for technology assessment also includes organizational factors like structure, flexibility for change and decision making, social factors such as religion, taboos, language, concept of time, honor, respect and work ethics, cultural factors like taste, habit, and political factors such as political stability and corruption. The last factor for the technology assessment is Environmental factors which includes geographical and climatic condition, ecological systems, and effects of pollution, resource depletion and environmental destruction.

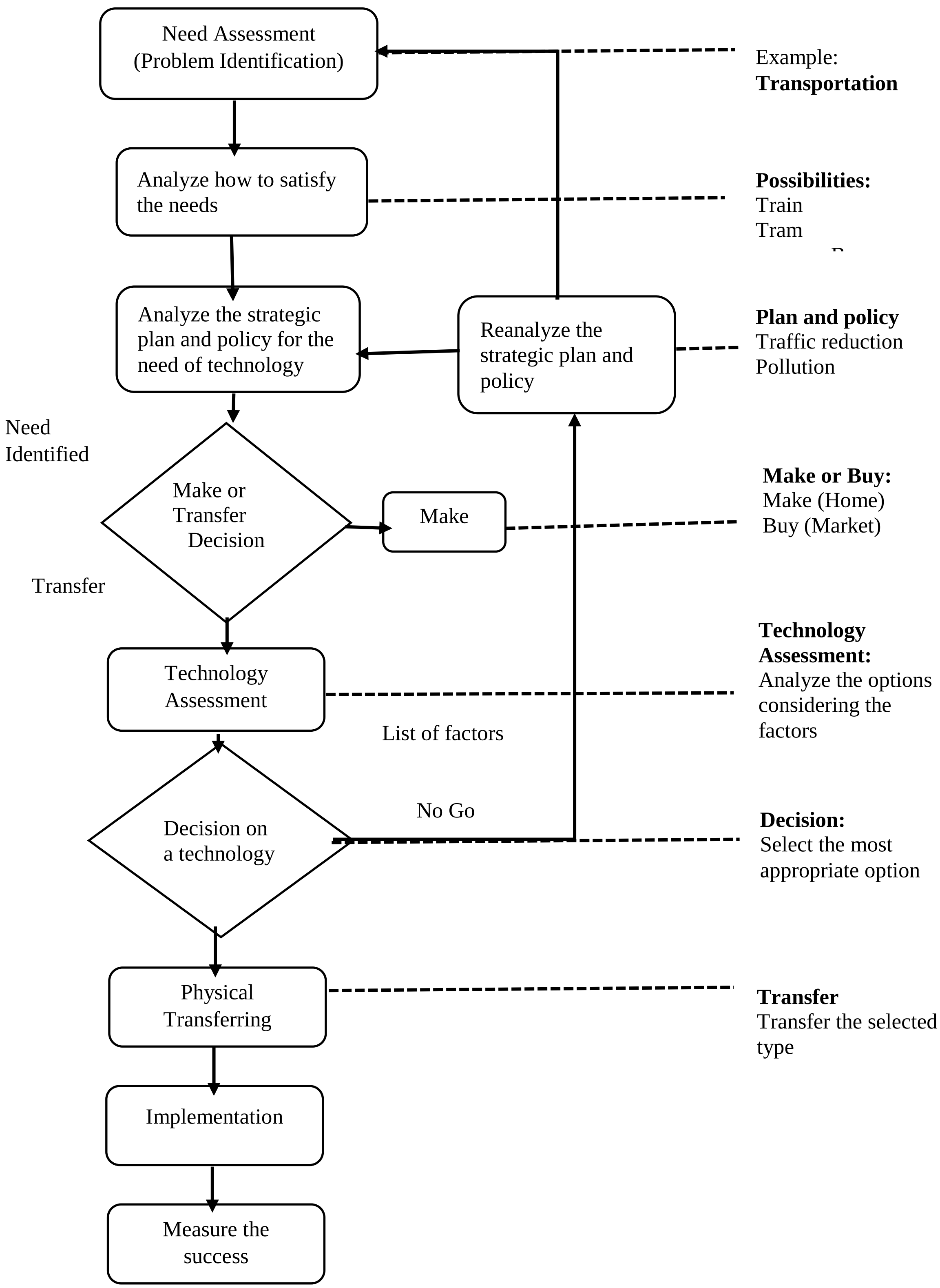

Fig 2.8: Needs and Technology Assessment model

8. Transferee Driven Technology Transfer /Wubishet Jekale (2017)

The study made by Wubishet Jekale (2017) was considered the model for developing countries in general and for Ethiopian construction industry. The study identify the gaps by reviewing related works from different literature of different countries and from worldwide practices and Ethiopian practices in the capacity building for the construction industry. Existing best practices for the Ethiopian construction are described as follow:

- Using foreign constructors and consultants through subcontracting and Human Resource Development (HRD) employment opportunities
- Foreign multinational companies through foreign direct investment, franchise, agent ship and awareness creation
- Conferences, exhibitions, workshops, trade fairs by construction public bodies, societies, university
- Construction sector capacity building program (CSCBP)/ engineering sector capacity building program (ESCBP), university capacity building program (UCBP).
- Ministry of science and technology, Ethiopian construction project management institute university technology transfer initiative
- University-industry linkages

This research identified the following gaps for the Ethiopian

- Most CTT approach are too fragmented and created on by Government, Transferor led
- Most CTT approach placed transferor environment as prerequisite without recognizing itself
- Most CTT approach focused on no regulated and managed subcontracting and employment generated without explicit demand identification and articulated CTT program or project with appropriate KPI
- Most of CTT did not consider transferee willingness, absorption capacity, early participation and facilitators and barriers awareness creation
- Most CTT approach Organized without sufficient resources allocation including budget
- Focused only on inputs without perception towards ICT, chemicals and electro mechanicals technology

- Focused on social buildings and housing sub sectors

The study identifies ten CTT enablers, seven actors, ten priority TT methods/channels, five CTT phases with effectiveness outcomes. The phases on which CTT should follow were discussed below:

Phase 1: CT Transferee Selected

This phase concerned with CTT environment includes overall CTT policy environment, overall CTT sector priority, overall CTT development process priority, overall CTT product, service and works priority, overall CTT outcome, overall transferee priority, CTT transferee selection criteria, CTT effectiveness and value added (VA) criteria. And transferee it focused on in one direction and construction organizations professionals and occupational in the other direction.

Phase 2: CT Transferee Demand and Priority Determined

This phase focused on transferee demand and priority which includes transferee critical failure factors priorities, CTT with respect to cost, time, quality, priorities, CTT with respect to methods priorities, CTT with respect to inputs priorities, and CTT with respect to processes priorities. And conducive environment takes account of transferee TT demand, priority setting indicators, CTT effectiveness and VA indicators

Phase 3: CT Partner and Modes Selection

The third phase concerned with CT selection, transferor selection, process definition, model definition, channel definition, effectiveness and VA indicators, program development.

Phase 4: CTT Implementation

This phase paying attention on CT transferee, absorptive capacity, transferee experience in TT, transferee commitment and trust, transferee cultural and language situation, transferor knowledge base, transferor experience, transferor willingness, transferor local knowledge, transferor involvement of Diaspora as KTI and BCBLTE, transfer planning, mutual understanding and commitment.

Phase 5: CTT Outcomes Determination

The last phase concerned with CTT effectiveness which manly focused on TT environment conduciveness, transferee readiness level, selection of technology, partner and TT modes effectiveness, transferee transferor relationship effectiveness, transferor readiness and effectiveness during TT, TT effectiveness and value addition economic and knowledge advancement, TT effectiveness and value addition project performance. In other way direction CTT VA is focused on economic advancement, knowledge advancement and project performance. Requirements for improvement include planning, monitoring and evaluation. Taking the above concepts and the researcher developed the model for international TT model for developing country like Ethiopia.

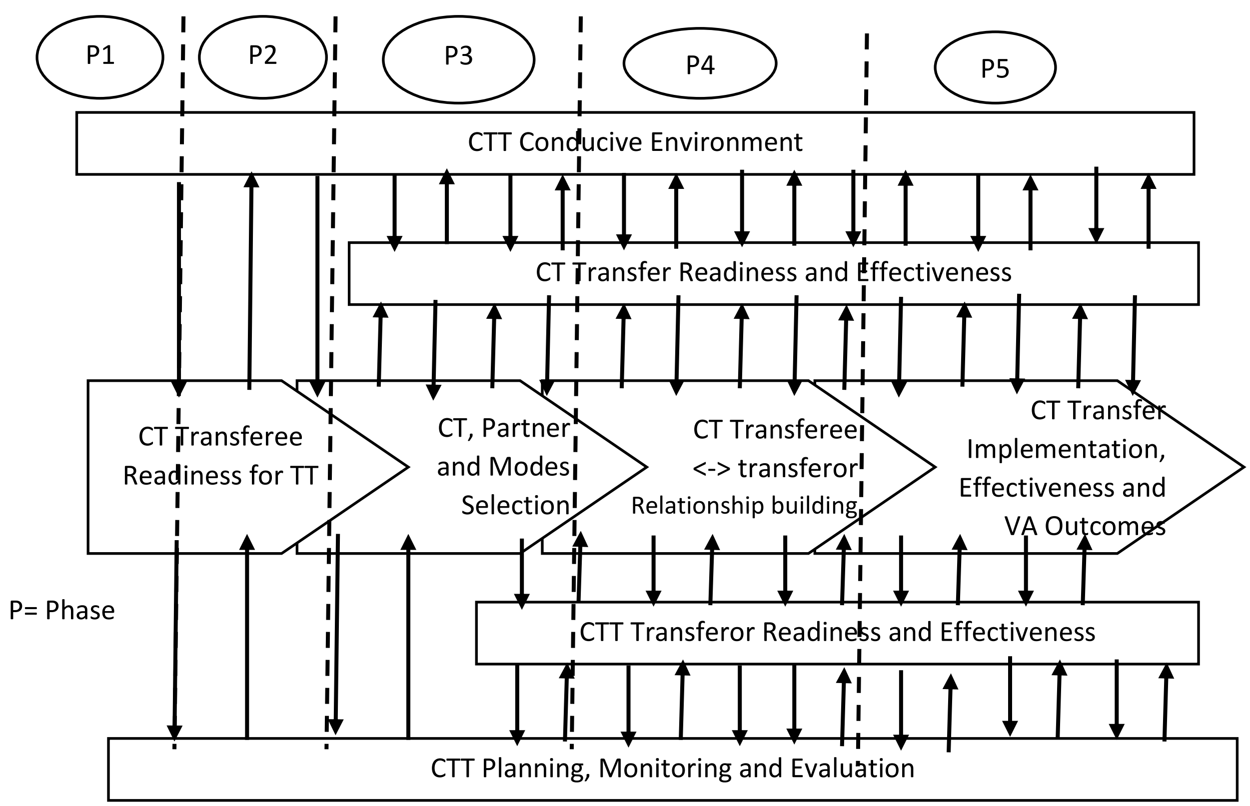

Fig 2.8: Transferee Driven Technology Transfee CTT Model

2.3.6. Critical analysis and research gap

There isn’t exists a complete model that describes the international process for construction project. Nonetheless there have been several previous studies that have identified many of the important factors for the TT that need to be incorporated when developing a conceptual TT model for construction projects. Although some of the studies may not have been specific to the construct sector they have identified issues that are generic and valid for several different industries. The gap and limitations of the existing models are presented as follow:

1. Calantone *et al* (1990) framework indicated to describe the feedback of international TT; but, fails to incorporate indicators for identifying the outcome of implementing technology. Furthermore, the model is extremely complex in design and has not been empirically verified through a robust statistical analysis regime. The model includes a number of factors which could be adapted for utilization of the construction context. The model as a whole is largely relevant for the marketing and logistics sector.

2. Simkoko (1992) model was undertaken examination of previously completed construction projects and presents one of the few addressing TT in construction. The research more directed at identifying how the involvement of local firms and personnel working on international construction projects was a function of project organization form management team and construction technology. The study provides only a limited understanding of the TT process as it only investigates the development of technological and management practices in the local industry rather than attempting to the model of TT enabling process. The model does not examine the impact of the transferee and transferor in the process and also the full value added from implementing TT initiatives other than competence development.

3. Lin and Berg (2001) framework identifies only three sets of factors that influence the TT process. For the construction industry this does not sufficiently describe all of the influential enabling and outcome factors. Important influences such as government policy mode of transfer have been neglected. Cultural difference was identified as a moderating

factor that has the most influence on the TT process as it has strong interaction effects with other factors. This research also fails to effectively describe the link between the TT process and the outcomes that may derive.

4. Malik (2002) intra-firm model does not closely examine the issues associated with the intent of the transferor to protect its core technology from its competitors and the possibility of differing project objective. Moreover, investigating into the outcome determination through TT programs was lacking in this model. Influencing factors have been identified but their impact on the project success measures requirement closer examination.

5. Wang e*t al* (2004) model main focuses on the foundation being based on case studies of multinational companies that are generalizable to theoretical propositions and not to the general population. Another drawback of the research is the intensive use of empirical evidence may have produced of theory that is over complex rather than parsimonious. The study also is limited by the scope of the TT process that was examined. The scope was confined to the amount of knowledge that a subsidiary of a multinational company acquires as a result of the transferor and transferee characteristics. Although these two enabler contracts are examined in sufficient detail the model fails to examine other influential factors such as government influence, technology characteristics.

6. Warookun (2007) model was developed based on the outcome of pilot study, primary study and case study. The research focused on variables transferee characteristics, transferor characteristics, learning environment, transfer environment, and TT value added discussed in detail. But, the limitation in the study is TT channels were note addressed in detail. The other limitation in the study was the new technology for the TT from abroad to local firm not identified on the model. The model didn’t address the technology transfer process stags appropriate for successful transferring the appropriate technology into local construction industry.

7. Kebede and Mudler (2008) model was developed to identify the technology transfer process starts from need identification to measuring the process. The limitation on the study is the mode of technology transfer not identified well. The other weakness of this study was it does not identify the enabler factors that play important role for the transfer of TT.

8. In the mine while Wubishet Jekale (2017) model developed by identifying the gaps by reviewing related works from different literature of different country and from worldwide practice with the Ethiopian practice in the capacity building for the construction industry. The limitation for this study is based on theoretical findings and it needs to evaluate the variables related to CTT for the Ethiopian construction industry statistically.

So, taking all the above gaps under consideration, this study tried to formulate a model by identifying the gaps and evaluated based on pilot study, primary source information and case study. And the result is also evaluated statistically. The research focused on variables transferee characteristics, transferor characteristics, learning environment, transfer environment, identifying new technology and TT value added discussed in detail. Moreover, it would address detail information and the new technology for the TT from abroad to local firm also identified in the model. Furthermore, the model tried to address the technology transfer process stags appropriate for successful CTT into the Ethiopian construction industry.

CHAPTER TREE

3. RESEARCH METHODOLOGY

This chapter includes the methodology used in this research work and provides information about the research design, study population, sampling techniques, research instrument, data collection, reliability and validity test, method of data analysis and model specification. It also discussed the process of data analysis. This gives justification in the choice of methods used to achieve the objective of the study.

3.1.Research Design

In order to investigate the construction technology transfer practices and development of technological capabilities, descriptive research design is applied; for the purpose of data collection the researcher used structured questionnaire. Sample is also selected from the population by statistical techniques to infer the population. To reduce the response error follow-ups were done by the researcher. And moreover, before the data was analyzed appropriate data editing activities have been carried out.

Such kind of research design is used because the researcher has no control over the variables, only a report of what has happened in the area where the research is conducted is taken. According to Kothari (2004), the major purpose of descriptive research is to describe the state of affairs as it exists at present.

Furthermore, based on the time sating, the study has used cross sectional study design. Thus, the survey method gathers data from a relatively large number of cases at a particular time.

All in all, in order to achieve the objective of this research a descriptive type of research followed by cross sectional studies was used. Accordingly, this study is concerned to investigate the construction technology transfer practices and development of technological capabilities of the Ethiopian constructions industry. Under the study, the existing construction technology transfer practices of the Ethiopian construction industry were assessed; the type of construction technology and TT mode applicable for the Ethiopia construction industry; and construction technology transfer model would have developed.

In order to achieve the objectives of this study and thereby give answers for the basic research questions, both qualitative and quantitative research approach, i.e., mixed research approach was used. For analyzing the data gathered from questionnaire, the researcher used quantitative approach. Quantitative research is selected to find out facts about a concept, question or an attribute and also to collect factual evidence and study the relationship between facts to test theory.

However, for the data gathered from interviews, case study and document analysis, the researcher used qualitative approach. It is selected to emphasize meanings, experiences, opinions, views, perceptions and attitudes towards the objects.

There are compelling reasons why the researcher opted to use mixed research approach. The adoption of positivist paradigm entails that measurement remains an essential element since its basic assumption is social phenomenon can be measured. This quantitative method was supplemented by a qualitative method to complement or validate information gathered from the quantitative survey, to gain deeper insights on the issue, to strengthen the analyses and thus enhance confidence in the conclusion.

3.2.Study population

The study population was all grade one contractors engaged in the construction industry. However, the target population of the study was grade one general contractor. According to ministry of construction (MoC) data the grade one general contractors participating in Ethiopia construction industry are 68 in 2010 E.C. Out of them five contractors are foreign, and other five firms selected purposively for the qualitative research inquires, because of they had a better technology transfer experience. So, they exclude from the population. Therefore, the target population of this study had been 58 firms. The final study units, had been the selected grade one construction firms those full fill all the stated criteria described in the scope of the study.

3.3.Sampling techniques

To select the required sample size, the researcher used both purposive and simple random sampling techniques. From the homogeneous list of grade one general contractors, samples were selected randomly. From them, the researcher took unites of the study.

Sampling is the process of selecting representative units of a construction parties for the study in research investigation. The advantage of using a sample is that it is more practical and less costly than collecting data from the contractors and consultant in general. The sampling technique used is probabilistic, random sampling, and non-probabilistic, purposive sampling techniques.

In order to select the appropriate sample size, the researcher used the formula used by Yamane (1967: 886) with sample size determination system with the consideration of 95% confidence interval as presented below. The researcher selects this sample size determination method because it is one of the best methods in determining the sample size in probability sampling method.

$$n = \frac{N}{1 + N(e^2)}$$

Where n = sample size

N = Total grade one general contractor in Ethiopia

e = Degree of precision = 5%

Therefore, to determine the required sample size with 95% confidence interval and 5% level of precision levels the sample size had been

$$n = \frac{58}{1 + 58(0.05)^2} \cong 50$$

Therefore, a sample of 50 contractors out of the total by simple random sampling technique had been selected.

3.4. Source of data

The study depended on both primary and secondary data. Primary data was made up of data collected by the candidate through the use of questionnaires, interviews and case study. Such data collection method uses for triangulation purpose to get multiple evidence in the study. The secondary sources of data were obtained using relevant books, journals, magazines, research papers and unpublished documents.

3.5. Research instrument

Multiple approaches were used for data collection. These are survey questionnaire, key informant interview and case study by taking the projects on which technology transfer is applied.

I. Survey Questionnaire

Questionnaire was selected as the research instrument owing to its suitability to the level of information required, cost and time limitations and the high number of respondents.

The structured questionnaire form, which was attended by a covering letter, consisted seven parts. The first part sought demographic information about the respondents' profile and the second part assesses the selection criteria/benefits for the new construction technology and the respondents were asked to rank the efficiency on benefits of the transfer. In the third part, participants were asked to rank the type of the new technology. The fourth part the respondents requested to rank the popular international construction technology transfer model used and its applicability on successful transfer of technology on the Ethiopian construction industries. The fifth part the respondents requested to rank the construction technology transfer process on which the stages on which transferee and transferor should follows for the transfer of technology on the Ethiopian construction industries. On the sixth part the respondents requested to rank the mechanism/channel used and its applicability on successful transfer of technology on the Ethiopian construction industries.

The last part of the questionnaire was asked about to create conducive environment for technology transfer includes transferee characteristics, transferor characteristics, relationship building and transfer environment. The rating values of 1, 2, 3, 4, and 5 were assigned to the options very low, low, adequate, high and very high respectively in obtaining the respondents' perception from part two up to part seven.

II. Interview

It is a face-to-face communication between interviewee and interviewer on certain area of inquiry, and thereby allows the interviewee to speak up freely and more data that are empirical might be directly obtained. Thus, using interview was important in order to support or strengthen the data gathered from the questionnaires. This data collection tool was also employing to gather detail information about the issue at hand from interviewee. Apart from use of questionnaires, a key informant interview was conducted.

III. Document Analysis

The documents including Growth and Transformation Plan (GTP), the federal democratic republic of Ethiopia science, technology and innovation policy (STI), university capacity building program (UCBP), construction sector capacity building program (CSCBP), the documents were used to clarify information gained from interviews and questionnaires and to corroborate researcher's understanding of policies and procedures with regard to technology transfer.

3.6. Data collection

The researcher adopted a three step data collection procedure. First, relevant literature was reviewed to get adequate information on the topic. Second, objectives and research questions were formulated to show the direction of the study. Third, data gathering tools were developed and a pilot test was conducted.

In addition, structured interviews were conducted and questionnaires were distributed by the researcher and by three data collectors so as to lead us to the desired point of information and to save time in line with the research design. Before the process of data collection began, the researcher gave training for the data collectors for one day. The development of the questionnaires involved the following steps: compiling a list of topics to be covered in the survey; discussing these topics with some professionals in the construction sector; and preparing a first and revised draft of the structured questions and the response formats.

The questionnaires were designed to gather both quantitative and qualitative data. After the data was collected using interviews; it was checked for its consistency and completeness before the final analysis was made.

3.7. Reliability and validity

Due attention was given to minimize the chance of getting higher errors. Hence, reliability and validity tests, which help to detect the presence or absence of those errors, have been carried out. To that end, the researcher has conducted pilot tests on 10 respondents after drafting the questionnaire to meet all the reliability and validity standards.

3.7.1. Validity Test

According to C.R. Kothari (2004), validity refers to the extent to which the instrument measures what the researcher(s) actually wish to measure. Validity is the most critical criterion that indicates the degree to which an instrument measures what it is supposed to measure.

In order to ensure the quality of this research, content validity of the instruments of the research was checked. The content validity was verified by the advisor, who looked into the appropriateness of the questions and the scales of measurement. Peer discussion with other researchers was also conducted since it is another way of checking the appropriateness of the questions. Moreover, copies of the questionnaire were distributed to ten respondents as a pilot test. This was done to decide whether the developed instruments measure what it was meant to measure and also to check the clarity, length, structure and wording of the questions. This test has helped the researcher to get valuable feedbacks to modify some questions.

3.7.2. Reliability Test

Reliability is concerned with whether the procedures of data collection and analysis will generate the same results on all occasions and whether others can also make similar observations and arrive at the same conclusions from the same given raw data. In other words, it is an attribute in which data collection procedures can be repeated with the same results. According to C.R. Kothari (2004), measuring instrument is reliable if it provides consistent results.

Moreover, in order to measure the consistency of the questionnaire a reliability test was carried out based on Cronbach's Alpha coefficient. Cronbach's Alpha can be interpreted as like a correlation coefficient. Its coefficient range lay on the value from 0 to 1. A reliability coefficient (alpha) higher than or equal to 0.7 is considered acceptable. That means, the formulated questions in the questionnaire are capable to meet the objective of the study.

Therefore, the reliability test conducted by the researcher has proved that all the items or attributes of the pilot questionnaire has been reliable since the results of the test were higher than 0.7 as indicated in the table below. Hence, the test results generated by all the variables used in this research are reliable enough for data analysis as their alpha value is greater than 0.7. Accordingly, because Cronbach's alpha for factors such as selection criteria of new technology, new construction technology for transfer, popular technology transfer model, technology transfer process and construction technology transfer channels are more than 0.7, it is statistically acceptable. In a similar manner, the Cronbach's alpha value for all items suggested that the data collected through questionnaires is reliable and can be used for further statistical analysis.

Table 3.1: Reliability Statistics

Variables	Cronbach's Alpha Based on Standardized Items	No. of Items
Selection criteria of new technology (success/Benefit factors)	0.811	5
New construction technology for transfer	0.751	44
Popular technology transfer model	0.803	9
Technology transfer process	0.771	9
construction technology transfer channels	0.749	11
Construction technology transfer conducive environment	0.962	24

Source: survey data, 2018

3.8.Method of Data Analysis

Simple statistical analysis involving tables, graphs, rankings and percentages were used in analyzing the results from the questionnaire. Based on the data obtained from the finding the study formulated the model for construction technology transfer. The collected data was analyzed and discussed using the computer software Statistical Package for Social Science version 24 (SPSS V.24) was used. The method of descriptive to give the detail description about the collected data and inferential statistics to determine the current and the future technology transfer was performed. Case study analysis and discussions were performed on the selected projects on which the CTT is applied to evaluate the effectiveness/validity of the model formulated for the Ethiopian construction technology transfer. Descriptive explanations were also employed in making the analysis more meaningful. In other way direction, descriptive statistic such as mean, percentages and frequency distributions, were prepared before a deeper analysis of data. And to determine the relationship among the variables, both the dependent and independent, and to give the basic research questions correlation and regression analysis were also used to meet the ordinary least square (OLS) assumptions of the linear regression. Finally, based on the findings formulate a beast construction framework which capable to boom the construction industry.

3.9.Model specification

For the purpose of this research, the following regression model is developed in order to identify the right factors that capable to affect the transfer of construction technology for the Ethiopian construction industry. The independent variables included in the model are new construction technology (x_{1i}), effectiveness of popular construction technology transfer mode (x_{2i}), technology transfer process (x_{3i}), technology transfer channel (x_{4i}) and conducive environment for technology transfer (x_{5i}). However, the dependent variable is the selection criteria for the benefit of technology transfer (Y_i).

The following regression model was used to indicate how the dependent variable is predicted by the independent variables.

$$Y_i = \alpha + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \beta_4 x_{4i} + \beta_5 x_{5i} + \varepsilon_i$$

Whereas, the variables are defined as:

Y_i= Selection criteria/benefit of new technology transfer
α = Constant term
$ß_i$ = Coefficients
x_{1i} = New construction technology;
x_{2i} = Effectiveness of popular construction technology transfer model;
x_{3i} = The technology transfer process;
x_{4i} = technology transfer channel; and
x_{5i} = Conducive environment.
ε_i = Error term

Under the assumptions of:

- ε_i ~N (0, 1) mean zero and variance 1
- Linear relationship between outcomes (y) and explanatory variable x
- Outcome variable (y) should be Normally distributed for each value of explanatory variable (x)
- Standard deviation of y should be approximately the same for each value of x
- Fixed independent observations
- The observations (explanatory variables) should be independent

3.10. Ethical considerations

Ethical issues play a determinant role during data collection. Cognizant of this fact, the researcher has given due attention and implemented serious steps to meet the ethical considerations related to the study. In line with this, the first page of the questionnaires has included an introductory opening letter that requests cooperation from respondents and to provide the appropriate response for the study. They were given assurance that the information they provide would be kept confidential. When data collections were made from study participants, all potential participants of the study were informed about the procedure that will be used in the study; the researcher explained the objectives and significance of the study to the respondents. To ensure this, the researcher has removed information that relates to the respondents' identity. Throughout data collection and any other activities that were related to the research, the researcher was maintained positive relationship with the respondents.

CHAPTER FOUR

4. RESULT AND DISCUSSIONS

4.1.Introduction

In this section, the study provided descriptive information on individual respondents and the projects they have worked on where construction technology transfer was incorporated. Specifically, this section provides a breakdown on name and types of their organization, years of experience on construction industries, and the number of projects that the respondents have been involved with. This information was necessary to confirm the validity of the results obtained and to develop an understanding of the background of respondents and the construction TT projects they have worked on.

4.2.Construction technology transfer practice in Ethiopia

4.2.1. *Response Error*

A total of 50 (100.0%) questionnaires have been distributed. Accordingly, 48 (96.0%) of the total respondents gave appropriate response for the given inquires. But, the remaining questionnaires have been found to be incomplete and insufficient for the analysis. Therefore in general around 4.0 % non-response error was considered.

Table 4.1: Representation of respondents

Sites Visited	Number of distributed Questionnaire	Number of returned questionnaire	Number of incomplete questionnaire	% of the responded questionnaires
Managers in GC1	50	48	2	96
Total	**50**	**48**	**2**	**96**

Source: Own data, 2018

4.2.2. *Respondents profile*

The table below shows that the type of organization where the respondents came from. All the entire 48 (100.0%) respondents are main contractors. This implies, the study mate its target because it is targeted to get information from the main contractors.

Table 4.2: Respondents work type

Variable	Category	Frequency	Percent
Type of the organization	Main Contractor	48	100.0

Source: Own data, 2018

Respondents work experience in the construction sector is detailed in Table 4.2. For instance a minimum experienced respondent had 5 year working practice in the sector, whereas, the maximum working skill recorded by the respondent were 30 years. On the average, every respondent had 16.4 (SD±7.6) years of working experience in the construction sector. This indicated that the entire respondents had better working experience in the sector.

Regarding the participation of new technology transfer, on the average every constructors participated in 5.2 (SD±4.2) new projects. But, on the new project participation all of the study participants are not involved. Rather 28 of the grade one contractors those are found in the country involved or participated in the CTT projects. This implies the new technology transfer practice is lower.

Table 4.3: Average work experience and number of CTT project participation

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Work experience in the construction sector	48	5	30	16.4	7.6
Numbers of CTT projects respondents involve	28	1	16	5.2	4.2

Source: Own data, 2018

4.2.3. Selection criteria

As indicated in the tables below, the mean value of the responses perception levels of the entire items are above the median threshold (3). High mean scores which are higher than the median value (3) indicate the positive attitude and low mean score indicates the negative attitude towards success related factors. In that regards, in the case of these particular items most of the study participants average perception level tilted into the appropriate direction. Moreover, the variations also do not that much more deviate from the average, so, there is no strong disparity among the respondents perception.

Each selected criteria items are explored further with relation to construction transfer technology. The indicators were given and the respondents were asked to pick from a Likert-scale ranging from 'very low to very high'. Hence, responses for questions asked to identify whether the quality and productivity such as no rework and minimize wastage had improved in the construction sector or not. Accordingly, the mean score of this item is higher than all remaining items which indicate that the improvement of quality was nice. That is, most of the respondents, 25 (52.1%), said the improvement is very high and 13 (27.1%) implied high quality improvement was recorded in the sector, whereas, 4 (8.3%) study participants oppose these respondents response. Of course, this result indicates as the vast respondents' opinion the construction sectors are working in quality.

The next highest ranked item is whether the construction sector level of knowledge improved time to time or not. As the result indicated, 17 (41.1%) respondents said the level of improvement is very high, and 20 (41.7%) said high; while, 4 (8.3%) respondents confirmed that the level is low. This illustrated that as most respondents believe the construction sector improved knowledge and working practice.

About 15 (31.3%) of the total respondents convinced that the timely completion of the projects, i.e., delivering the project on time and minimizing the idleness are very high and 18 (37.5%) respondents said high. However, 5 (10.4%) respondents oppose the above respondent argument. Likewise, as per 34 (64.6%) respondents' opinion the construction sector had minimize the cost overrun such as minimize wastage beyond tolerance and minimize non compensable losses. In both cases only few respondents confirmed low level of implementation. This implies that as per the most respondents opinion the cost overrun and timely completion of a project minimize and improved time to time.

Moreover, 14 (29.2%) respondents were convinced that the safety performance of the sector is improved. The other 13 (27.1%) study participants strongly support the above opinion, while, 4 (8.4%) respondents disagreed with the idea. So, more than ½ of the study participants convinced the construction safety performance improved, therefore, the accident related with safety reduced.

Table 4.4: Success or benefit related factors for the selection of technology transfer

Statement	Level of Perception						
	Very Low	**Low**	**Adequate**	**High**	**Very High**	**Mean**	**Std. deviation**
Improved knowledge and working practice (project management techniques, engineering and construction techniques, IT system)	2 (4.2%)	1 (2.1%)	8 (16.7%)	20 (41.7%)	17 (35.4%)	4.02	1.01
Improved quality and productivity (no rework, minimize wastage)	0 (0.0%)	4 (8.3%)	6 (12.5%)	13 (27.1%)	25 (52.1%)	4.23	0.97
Minimize cost overrun (minimize wastage beyond tolerance, minimize non compensable losses)	0 (0.0%)	2 (4.2%)	15 (31.3%)	17 (35.4%)	14 (29.2%)	3.90	0.88
Timely completion (no delivery delay, Minimize idleness)	0 (0.0%)	5 (10.4%)	10 (20.8%)	18 (37.5%)	15 (31.3%)	3.90	0.97
Improved safety performance (minimize accident)	3 (6.3%)	1 (2.1%)	17 (35.4%)	14 (29.2%)	13 (27.1%)	3.69	1.10

Source: Own data, 2018

4.2.4. New technology for technology transfer

4.2.4.1. Earth work

Mini excavator for tight and confined areas is one of the items which considered under the earth working. According to the majority of the study participants, 30 (54.2%), points of view, this machine is highly applicability in the construction sector, while, 4 (8.4%) of the other respondents oppose those respondents argument rather it is least relevant. When those respondents evaluate the benefit of this machine, 16 (33.3%) study participants informed that it is used to minimize cost of construction on confined area, likewise 12 (25.0%) of the other study participants said the machine helps to complete the work on time. But, limited respondents, 3 (6.3%), informed that the machine is used to gain improve knowledge and working practice.

The effectiveness of spider excavator on the construction work is also evaluated. Among the total participants 13 (27.1%), respondents opinion, it is very highly relevant in the construction sector. Likewise, 13 (22.9%) study participants strongly support the above respondents' opinion, while, 6 (12.6%) respondents opposed the above respondents ideas. Relatively, when they evaluate the advantage of this machine 16 (33.3%) said to complete their job on time, 14 (29.2%) said to improve quality and productivity; in addition, 8 (16.7%) respondents informed that it is helpful to minimize construction cost.

The respondents also evaluate the effectiveness and benefit of tunnel boring machine. Accordingly, the respondents, 17 (35.4%), convinced that this machine is highly applicability in the construction sector, while, 13 (27.3%) of the other respondents oppose those study participants argument. Moreover, the study tried to evaluate the success of this tunneling technology, as a result 14 (29.2%) of the respondents recognized that it is important to improve safety performance in tunneling work, similarly 12 (25.0%) of the participants supposed the machine helps to lower the cost of excavation of tunnel. Similarly, 9(18.8%) respondents said the machine minimize the completion time of the project, others 8 (16.7%) respondents informed that the machine is used to maximize quality and productivity of the sector. But, few respondents, 5 (10.4%), cognizant the machine is more important to develop new knowledge and working practice. The table below illustrates more information about the earth work technology (Table 4.5).

Table 4.5: Earth work

Earth Work	**Efficiency**					**Selection criteria (Success/ benefit related factors)**				
	Very Low	**Low**	**Adequate**	**High**	**Very High**	**1**	**2**	**3**	**4**	**5**
Spider excavators (used in every terrain)	3 (6.3%)	3 (6.3%)	16 (33.3%)	13 (27.1%)	13 (27.1%)	6 (12.5%)	14 (29.2%)	8 (16.7%)	16 (33.3%)	4 (8.3%)
Mini excavators (for tight and confined areas)	2 (4.2%)	2 (4.2%)	14 (29.2%)	16 (33.3%)	14 (29.2%)	3 (6.3%)	9 (18.8%)	16 (33.3%)	12 (25.0%)	8 (16.7%)
Articulated hauler (to transport loads over rough terrain)	3 (6.3%)	1 (2.1%)	22 (45.8%)	10 (20.8%)	12 (25.0%)	3 (6.3%)	9 (18.8%)	15 (31.3%)	13 (27.1%)	8 (16.7%)
Tunnel boring machine(TBM)	9 (18.8%)	4 (8.3%)	18 (37.5%)	5 (10.4%)	12 (25%)	5 (10.4%)	8 (16.7%)	12 (25.0%)	9 (18.8%)	14 (29.2%)

1. Knowledge 2. Quality and productivity 3. Minimize cost 4.Timely completion
5. Safety performance
Source: Own data, 2018

4.2.4.2.Floors walls and slabs

In this section the study asked the respondent to evaluate their opinion about the effectiveness of pre-fabricated and assembly system. Therefore, 19 (39.6%) respondents responded that the system is very largely applicable for the construction sector. Similarly, 18 (37.5%) study participants said the system is highly relevant, whilst, overwhelming, 4 (8.4%) respondents acknowledged that the level of applicability of the system is low. Regarding their evaluation, the system is used to complete the job on time said 15 (31.3%) respondents. Moreover, 12 (25.0%) respondents said it is used to improve quality and productivity, 10 (20.8%) said to minimize cost, and 7 (14.6%) said to improves safety performance in the field of construction industry to transfer liquid concrete.

Bubble deck slab flooring which uses to reduce the weight of the slab for multistory building is highly relevant for the construction sector said 23 (47.9%) respondents. In contrast 4 (8.3%) study participants informed that the level of applicability of this material is very low. When the study evaluate the perception of the respondents about this technology 17 (35.4%) said it helps to improves the new knowledge, 16 (33.3%) said to minimize cost. But, 4(8.3%) respondents said it is used to complete the job on time, likewise, the other 4 (8.3%) respondents said to improve safety performance for the use of bubble deck slab flooring in the construction industry.

Regarding to the self-cleaning glass windows, the vast majority of the respondents, 22 (45.8%), informed that it is highly applicable for the construction industry, while, 11 (22.9%) respondents oppose the above study participants argument rather they said the material has least relevancy for the industry. The participants also evaluate the success of this technology, so, 15 (31.3%) study participants acknowledged that the material is used to minimize cost, alike, 10 (20.8%) other respondents informed that the material used to complete task on time. The table below elaborated more about the above issues (Table4.5).

Table 4.6: Floors walls and slabs

Floors walls and slabs	Efficiency					Selection criteria (Success/ benefit related factors)				
	Very Low	Low	Adequate	High	Very High	1	2	3	4	5
Pre-fabricated and assembly system	3 (6.3%)	1 (2.1%)	7 (14.6%)	18 (37.5%)	19 (39.6%)	4 (8.3%)	12 (25.0%)	10 (20.8%)	15 (31.3%)	7 (14.6%)
Pre-cast system (Manufactured off-site)	2 (64.2%)	4 (8.3%)	9 (18.8%)	12 (25.0%)	21 (43.8%)	5 (10.4%)	15 (31.3%)	7 (14.6%)	14 (29.2%)	7 (14.6%)
Bubble Deck slab	4 (8.3%)	0 (0%)	21 (43.8%)	12 (25.0%)	11 (22.9%)	17 (35.4%)	7 (14.6%)	16 (33.3%)	4 (8.3%)	4 (8.3%)
Ezy Profile-slab profiling tool	5 (10.4%)	1 (2.1%)	18 (37.5%)	18 (37.5%)	6 (12.5%)	7 (14.6%)	7 (14.6%)	12 (25.0%)	7 (14.6%)	15 (31.3%)
Self-cleaning glass windows	6 (12.5%)	5 (10.4%)	15 (31.3%)	10 (20.8%)	12 (25.0%)	6 (12.5%)	8 (16.7%)	15 (31.3%)	10 (20.8%)	9 (18.8%)

1. Knowledge 2. Quality and productivity 3. Minimize cost 4. Timely completion
5. Safety performance
Source: Own data, 2018

4.2.4.3.Temporary structures (Formworks)

According to most respondents, 21 (43.8%), opinion in the formwork of the construction work, steel panel modular formwork with used on large projects or reuses of the shuttering is very greatly relevant in the construction industry. Likewise, 18 (37.5%) respondents agreed with the above respondents' opinion. But, 4 (8.4%) respondents oppose against the above study participants argument; rather as per their opinion it is least applicability in the sector. When the respondents evaluate the advantage of steel panel modular formwork, 20 (41.7%) respondents said it is used to improve safety performance and 12 (25.0%) other respondents said it is applicable for completion the work on time. But few study participants, 3(6.3%), convinced that it is used to improve new knowledge.

Plastic formwork systems is also highly relevant material for the construction sector said most respondents, 22 (45.8%). Nevertheless, 4 (8.4%) study participants arguing that the level of applicability is below what they expected. When they evaluate its benefit, 15 (31.3%) of the respondents informed that the material helps to minimize cost, likewise, 13(27.1%) respondents said it used to complete the job on time.

Regarding the temporary structure of construction industry, 17 (35.4%) respondents convinced that movable formwork is highly relevant, while, 13 (27.1%) study participants arguing that the level of applicability of this framework is low. Jointly the study tried to evaluate the respondents opinion about the benefit of this technology, as a result 16 (33.3%) of the respondents informed that the framework used to minimize cost, similarly, 12 (25.0%) respondents said it is used to complete the task on time. The below table illustrated more about the above issue (Table 4.6).

Table 4.7: Temporary structures (Formworks)

Temporary structures (Formworks)	Efficiency					Selection criteria (Success/ benefit related factors)				
	Very Low	Low	Adequate	High	Very High	1	2	3	4	5
Steel panel modular formwork	2 (4.2%)	2 (4.2%)	5 (10.4%)	18 (37.5%)	21 (43.8%)	3 (6.3%)	7 (14.6%)	6 (12.5%)	12 (25.0%)	20 (41.7%)
Aluminum formwork system	2 (4.2%)	2 (4.2%)	14 (29.2%)	16 (33.3%)	14 (29.2%)	3 (6.3%)	9 (18.8%)	16 (33.3%)	12 (25.0%)	8 (16.7%)
Plastic formwork systems	3 (6.3%)	1 (2.1%)	22 (45.8%)	10 (20.8%)	12 (25.0%)	3 (6.3%)	9 (18.8%)	15 (31.3%)	13 (27.1%)	8 (16.7%)
Movable formwork	9 (18.8%)	4 (8.3%)	18 (37.5%)	5 (10.4%)	12 (25%)	5 (10.4%)	8 (16.7%)	12 (25.0%)	9 (18.8%)	14 (29.2%)

1. Knowledge 2. Quality and productivity 3. Minimize cost 4. Timely completion
5. Safety performance

Source: Own data, 2018

4.2.4.4.Reinforcement

The effectiveness of mesh bending and cutting machine on the construction work also evaluated. According to the majority, 26 (54.2%), of the study participants points of view, it is very highly applicable in the construction sector. Moreover, 11 (22.9%) respondents strongly support the above respondents' opinion, while, 4 (8.4%) respondents said the level of applicability is low. Relatively, when they evaluate the advantage of this machine 18 (37.5%) said to complete their job on time, 12 (25.0%) said to improve, whereas, 5 (10.4%) respondents informed that it is helpful to improve the new knowledge. The below table illustrated more about mesh bending and cutting machine (Table4.8).

Automatic rebar tying is the other item which considered in this section. Most of the respondents, 26 (44.1%), convinced that this machine is highly applicability in the construction sector, while, 12 (25.0%) of the respondents oppose those respondents argument. When the study participants evaluate the benefit of this reinforcement technology 26 (54.3%) of the respondents acknowledged that it is used to complete the job on time, likewise 8 (16.7%) of the participants said the machine helps to improve quality and productivity. But, few respondents, 3 (6.3%), informed the machine is used to minimize cost in the construction industry.

About 18 (37.5%) respondents informed that shaping centers is greatly relevant for the construction sector. However, 7(14.6%) study participants said the level of applicability is very low, likewise, 2(4.2%) respondents said the applicability is low. Regarding the participants evaluation about the benefit of this concrete technology, 16(33.3%) respondents said it is important to improve quality and productivity and other 16 (33.3%) respondents said it helps to minimize cost. But, only 3(6.3%) respondents convinced that the machine is used to improve safety performance in the construction industry. For more detail information, look at the table below (Table 4.8).

Table 4.8: Reinforcement

Reinforcement	**Efficiency**					**Selection criteria (Success/ benefit related factors)**				
	Very Low	**Low**	**Adequate**	**High**	**Very High**	**1**	**2**	**3**	**4**	**5**
Mesh bending and cutting machine)	3 (6.3%)	1 (2.1%)	7 (14.6%)	11 (22.9%)	26 (54.2%)	5 (10.4%)	6 (12.5%)	7 (14.6%)	18 (37.5%)	12 (25.0%)
Mesh welding machine	7 (14.6%)	2 (4.2%)	17 (35.4%)	9 (18.8%)	13 (27.1%)	4 (8.3%)	10 (20.8%)	10 (20.8%)	20 (41.7%)	4 (8.3%)
Shaping centers	7 (14.6%)	2 (4.2%)	21 (43.8%)	11 (22.9%)	7 (14.6%)	5 (10.4%)	16 (33.3%)	16 (33.3%)	8 (16.7%)	3 (6.3%)
Reinforcement bar coupler	2 (4.2%)	4 (8.3%)	11 (22.9%)	14 (29,2%)	17 (35.4%)	6 (12.5%)	9 (18.8%)	18 (37.5%)	11 (22.9%)	4 (8.3%)
Automatic rebar tying machine	5 (10.4%)	7 (14.6%)	10 (20.8%)	10 (20.8%)	16 (33.3%)	4 (8.3%)	8 (16.7%)	3 (6.3%)	26 (54.3%)	7 (14.6%)

1. Knowledge 2. Quality and productivity 3. Minimize cost 4. Timely completion 5. Safety performance **Source**: Own data, 2018

4.2.4.5.Concrete works

The respondent requested to evaluate the effectiveness of concrete pumps on the construction work, so as 30 (62.5%) respondents response the machine is desirable in a very high, and 7 (14.6%) other study participants said in high level; while, 5 (10.4%) respondents informed that the level of applicability of this machine is very low. Relatively the participants asked to evaluate why the concrete pump is needed; as the respondents evaluation it helps to improve quality and productivity, 13(27.1%), to improve safety performance, 13(27.1%), to complete a task on time 12(25.0%), to minimize cost 8(16.7%) and to improve the new knowledge, 2(4.2).

According to 19(39.6%) respondents response, cast-in-place booms is highly relevance in the construction sector, equally, 13(27.1%) respondents strongly support this idea. In contrast, 5 (10.5%) study participants said that the level of applicability of this machine is low. When the respondents evaluate its benefit 14 (29.2%) said to improve quality and productivity, 12 (25.0%) to complete the job on time, and 10 (20.8%) to minimize cost.

Fiber Reinforced Concrete (FRC) is the lowest ranked item in this category. The result gathered from respondent indicates out of the entire participants 12 (25.0%) of them convinced that this machine is very high relevance and 9(18.8%) said high relevance for the construction industry. However, 13 (27.1%) respondents oppose against the above respondents opinion, so they said the level of applicability of this item is low. Jointly, participants evaluate the benefit of this concrete technology, as their opinion 18 (37.5%) respondents said to improve the new knowledge, 14 (29.2%) said to improve quality and productivity, 9 (18.8%) implies to minimize cost, 5 (10.4%) reported to complete a job on time and 2(4.2%) said to improve safety performance in the construction industry.

Table 4.9: Concrete works

Concrete works	**Efficiency**					**Selection criteria (Success/ benefit related factors)**				
	Very Low	**Low**	**Adequate**	**High**	**Very High**	**1**	**2**	**3**	**4**	**5**
Concrete pumps	1 (2.1%)	4 (8.3%)	6 (12.5%)	7 (14.6%)	30 (62.5%)	2 (4.2%)	13 (27.1%)	8 (16.7%)	12 (25.0%)	13 (27.1%)
Cast- in- place Booms (stationary placement booms)	2 (4.2%)	3 (6.3%)	11 (22.9%)	19 (39.6%)	13 (27.1%)	4 (8.3%)	14 (29.2%)	10 (20.8%)	12 (25.0%)	8 (16.7%)
FRC (Fiber reinforced concrete)	4 (8.3%)	9 (18.8%)	14 (29.2%)	9 (18.8%)	12 (25.0%)	18 (37.5%)	14 (29.2%)	9 (18.8%)	5 (10.4%)	2 (4.2%)
Admixture chemicals	2 (4.2%)	2 (4.2%)	9 (18.8%)	9 (18.8%)	26 (54.2%)	3 (6.3%)	14 (29.2%)	9 (18.8%)	15 (31.3%)	7 (14.7%)
Automatic Concrete screening machine	6 (12.5%)	2 (4.2%)	15 (31.3%)	11 (22.9%)	14 (29.2%)	8 (16.7%)	18 (37.5%)	8 (16..7%)	10 (20.8%)	4 (8.3%)

1. Knowledge 2. Quality and productivity 3. Minimize cost 4.Timely completion
5. Safety performance

Source: Own data, 2018

4.2.4.6.Block masonry

The respondent requested to rank the effectiveness of movable or stationary block making machine on the construction work. As the result indicated, most of the respondents, 21 (43.8%), informed that the machine is very highly essential for the construction industry; 18 (37.5%) other also highly support the above respondents opinion, whilst, 4 (8.4%) respondents oppose against the above respondents idea. Rather as per their opinion this machine do have a low level of applicability in the construction sector. In line with the above issue, participants asked to evaluate the benefit of the movable/stationary block making machine, so, 20 (41.7%) of the respondents said it is important to improve safety performance, 12 (25.0%) said to complete the work on time and 7 (14.6%) informed it improves quality and productivity. The below table illustrated more about the above concepts (Table4.10).

Mobile mortar mixer is highly applicable for construction industry said 30 (62.5%) respondents, unlike those respondents 4 (8.4%) informed that the level of applicability of this item is low. Regarding to the respondents evaluation about the benefit of this technology 16 (33.3%) said it use to minimize cost, 12(25.0%) to complete a task on time, 9(18.8%) to improve quality and productivity, 8(16.7%) acknowledged to improve safety performance and 3(6.3%) said to improve the new knowledge in the construction industry.

Table 4.10: Block masonry

Block masonry	Efficiency					Selection criteria (Success/ benefit related factors)				
	Very Low	Low	Adequate	High	Very High	1	2	3	4	5
Movable/stationary block making machine	2 (4.2%)	2 (4.2%)	5 (10.4%)	18 (37.5%)	21 (43.8%)	3 (6.3%)	7 (14.6%)	6 (12.5%)	12 (25.0%)	20 (41.7%)
Mobile mortar mixer with a Tele- handler	2 (4.2%)	2 (4.2%)	14 (29.2%)	16 (33.3%)	14 (29.2%)	3 (6.3%)	9 (18.8%)	16 (33.3%)	12 (25.0%)	8 (16.7%)

1. Knowledge 2. Quality and productivity 3. Minimize cost 4.Timely completion
5. Safety performance

Source: Own data, 2018

4.2.4.7.Finishing Works

For finishing work the respondent asked to evaluate their perception on the efficiency of finishing instrument, so, plastering machine and airless spray painting machine take a higher positive rank. According to the result reviled in the table below out of the entire participants 15 (31.3%) of them said the plastering machine required a very high relevance, likewise, 13 (27.1%) respondents give a higher priority. But, 5 (10.4%) study participants informed that the level of applicability is low. When they evaluate the benefit of this material the majority of the respondents, 18 (37.5%), said it is capable to minimize a loss of time. The other 12 (25.0%) study participants evaluate the plastering machine which enables to render on bricks and concrete blocks can improve the quality and productivity. For the more detail information, look at the table below (Table 4.11).

According to the airless spray painting machine concern, 17 (35.3%) respondents said highly and 15 (31.3%) respondents very highly applicable in the construction sector, whereas, 7 (14.6%) study participants oppose the above respondent opinion. Jointly, the participants evaluate the benefit of this equipment; accordingly, 18 (37.5%) of them informed that it is used to complete their job on time and other 12 (25.0%) respondents acknowledged that the machine helps to improve the new knowledge, similarly, 12 (18.8%) respondents reported that the airless spray painting machine helps to improve quality and productivity. The below table illustrated more about this subject (Table4.11).

Moreover, 15 (31.3%) study participants said glass tiles, which manufactured piece of hard wearing glass used for floors, walls, showers, highly applicable in the construction sector. Similarly, 4 (8.3%) study participants convinced that the glass tiles needed to be a very high relevance for the construction sector, whereas, 14 (29.2%) respondents oppose the above respondents argument. In the case of benefit of this finishing material 20 (41.7%) respondents said it use to improve the new knowledge, 14 (29.2%) said to improve quality and productivity, 9 (18.8%) informed to minimize cost, 3(6.3%) thought to complete the job on time and 2 (4.2%) improves safety performance in the construction industry to controls water migration through concrete masonry and brick walls.

Table 4.11: Finishing Works

Finishing Works	Efficiency					Selection criteria (Success/ benefit related factors)				
	Very Low	**Low**	**Adequate**	**High**	**Very High**	**1**	**2**	**3**	**4**	**5**
Plastering machine	4 (8.3%)	1 (2.1%)	15 (31.3%)	13 (27.1%)	15 (31.3%)	6 (12.5%)	12 (25.0%)	7 (14.6%)	18 (37.5%)	5 (10.4%)
Glass Tiles	8 (16.7%)	6 (12.5%)	15 (31.3%)	15 (31.3%)	4 (8.3%)	20 (41.7%)	14 (29.2%)	9 (18.8%)	3 (6.3%)	2 (4.2%)
Airless spray painting machine	6 (12.5%)	1 (2.1%)	9 (18.8%)	17 (35.3%)	15 (31.3%)	10 (20.8%)	8 (16.7%)	8 (16.7%)	12 (25.0%)	10 (20.8%)

1. Knowledge 2. Quality and productivity 3. Minimize cost 4. Timely completion
5. Safety performance

Source: Own data, 2018

4.2.4.8.Water proofing materials

In the water proofing material the first technology tried to address in this study is the damp proofing cream (DPC) technology. As the result indicated out of the entire participants 18 (37.5%) of the participants said high and 15 (31.3%) said DPC is very highly desirable for the construction sector, whereas, 4(8.3%) said that the level of applicability is very low and 1(2.1%) low. The participants evaluate the benefit of DPC and convinced 14 (29.2%) improves safety performance, 10(20.8%) to complete on time, 9 (18.8%) minimize cost, 9(18.8%) improves quality and productivity, and 6 (12.5%) improves the new knowledge in the field of construction industry which applied into base wall.

Likewise, most respondents support masonry water proofer is essential for the effectiveness of construction technology. That is, the majority of the respondents, 15 (31.3%), convinced that masonry water proofer needed to be given very high, and 13 (27.1%) said high importance to enhance the effectiveness of the construction sector; whilst, 3 (6.3%) respondents said that the level of applicability is very low and 2(4.2%) said low. Regarding to the benefit 15 (31.3%) study participants informed that it helps to improve quality and productivity, 11 (22.9%) said to minimize cost, 8(16.7%) informed to improve safety performance, 7(14.6%) to improve the new knowledge, and 7(14.6%) to complete on time in the construction industry to controls water migration through concrete masonry and brick walls.

Table 4.12: Water proofing materials

Water proofing materials	Efficiency					Selection criteria (Success/ benefit related factors)				
	Very Low	Low	Adequate	High	Very High	1	2	3	4	5
Masonry water proofer	3 (6.3%)	2 (4.2%)	15 (31.3%)	13 (27.1%)	15 (31.3%)	7 (14.6%)	15 (31.3%)	11 (22.9%)	7 (14.6%)	8 (16.7%)
Damp proofing cream (DPC)	4 (8.3%)	1 (2.1%)	10 (20.8%)	18 (37.5%)	15 (31.3%)	6 (12.5%)	9 (18.8%)	9 (18.8%)	10 (20.8%)	14 (29.2%)

1. Knowledge 2. Quality and productivity 3. Minimize cost 4. Timely completion 5. Safety performance

Source: Own data, 2018

4.2.4.9.Information and communication technology

e-business technology is one of the information and communication technology tried to address in this study. As the result reviled in the table below, out of the entire participants 14 (29.2%) of them convinced that the technology desirable to be given very high, and 7(14.6%) said high effect on the construction sector; whereas, 6(12.5%) said the level of applicability is very low and 6(12.5%) low. The participants evaluate the benefit of e-business and convinced that 19(39.6%) respondents said it improves the new knowledge, 10 (20.8%) to complete a project on time, 7 (14.6%) to minimize a cost, other 7 (14.6%) respondents informed that helps to improve safety performance and 5 (10.4%) improves quality and productivity in the field of construction industry especially for procurement.

The next highest ranked item is Building Information Modeling (BIM). Accordingly, the vast majority of the respondents, 18 (37.5%), arguing this item adequately important for the effectiveness of construction technology. Moreover, 10 (20.8%) other respondents convinced that the BIM is very highly effective in most construction industries, and 8 (16.7%) other study participants highly support the above respondents opinion. In contrast, 6 (12.5%) respondents said that the level of applicability is very low, likewise, 6 (12.5%) said low. When the participants evaluate the benefit 30 (62.5%) acknowledges that it helps to improve the new knowledge, 7 (14.6%) minimize cost, 5 (10.4%) to complete on time, 4 (8.3%) improves quality and productivity and 2 (4.2%) improves safety performance in the construction industry.

3D printing is also the other item under considered in this study. As the study findings indicated, out of the entire participants 15 (10.8%) of them convinced that 3D printing needed to be given very high, and 3 (6.3%) said high effect on the construction industry. Although, 9 (18.8%) respondents said the level of applicability is very low, similarly, 7 (14.6%) other said low. Regarding to the participants evaluation about 3D printing success the vast majority of the respondents, 25 (52.1%), informed, it is helpful for improve the new knowledge, 10 (20.8%) said for improves quality and productivity, 9 (18.8%) thought to minimize cost, 3 (6.3%) study participants supposed to complete on time and 1 (2.1%) said to improve safety performance for the Ethiopian construction industry.

The respondents also asked to evaluate their perception level about the Ground Penetrating Radar (GPR). According to the majority, 11 (22.9%), of the respondents response GPR is very highly applicable, and 10 (20.8%) said highly applicable in the construction sector. However, 11 (22.9%) respondents informed that the level of applicability is very low, likewise, 5 (10.8%) respondents said low. The participants evaluate the success of this technology and convinced 27 (56.3%) improves the new knowledge, 8 (16.7%) to complete on time, 6 (12.5%) improves quality and productivity, 4 (8.3%) improved safety performance and 3 (6.3%) minimize cost for the construction works.

Respondents also requested to evaluate the information and communication technology of 3D hand held computer applicability in the construction sector. As the result shows, out of the entire respondent 11 (22.9%) of them convinced that 3D hand held computers needed in a very high, and 5 (10.4%) high applicability, while, 10 (20.8%) respondents said the level of applicability is very low, likewise, 3 (6.3%) others said it is low. Jointly, the respondents also evaluate the benefit of this technology. Accordingly, the majority of the respondents, 29 (60.4%), informed it is helpful for the improvement of new knowledge, 8 (16.7%) said for the improvement of quality and productivity, 7 (14.6%) said to minimize cost and 4 (8.3%) for the safety performance of the construction industry.

The spectra precision laser scanning technology applicability level is also evaluated by the respondents. From the entire respondent 9 (18.8%) of them said the relevancy is high, likewise, 7

(14.6%) respondents convinced that spectra precision laser scanning is needed very highly. However, 15 (33.3%) study participants oppose the above respondent opinion. Regarding the benefit and evaluate of this technology, most of the study participants, 31 (64.6%), informed that the technology helps to improve the new knowledge, 6 (12.5%) said it assists to improve the quality and productivity, 4 (8.3%) said it minimizes cost, 5 (10.4%) respondents informed to complete the project on time and the remaining 2 (4.2%) respondents responded to improve safety performance for the construction works.

Table 4.13: Information and communication technology

Information and communication technology	Efficiency					Selection criteria (Success/ benefit related factors)				
	Very Low	Low	Adequate	High	Very High	1	2	3	4	5
3D hand held computers	10 (20.8%)	3 (6.3%)	19 (39.6%)	5 (10.4%)	11 (22.9%)	29 (60.4%)	8 (16.7%)	7 (14.6%)	0 (0%)	4 (8.3%)
3D printing	9 (18.8%)	7 (14.6%)	14 (29.2%)	3 (6.3%)	15 (31.3%)	25 (52.1%)	10 (20.8%)	9 (18.8%)	3 (6.3%)	1 (2.1%)
Building Information Modeling(BIM)	6 (12.5%)	6 (12.6%)	18 (37.5%)	8 (16.7%)	10 (20.8%)	30 (62.5%)	4 (8.3%)	7 (14.6%)	5 (10.4%)	2 (4.2%)
Ground Penetrating Radar (GPR) systems for civil works	11 (22.9%)	5 (10.4%)	11 (22.9%)	10 (20.8%)	11 (22.9%)	27 (56.3%)	6 (12.5%)	3 (6.3%)	8 (16.7%)	4. (8.3%)
Spectra precision laser Scanning	11 (22.9%)	5 (10.4%)	16 (33.3%)	9 (18.8%)	7 (14.6%)	31 (64.6%)	6 (12.5%)	4 (8.3%)	5 (10.4%)	2 (4.2%)
e-business technology (for procurement)	6 (12.5%)	6 (12.5%)	15 (31.3%)	7 (14.6%)	14 (29.2%)	19 (39.6%)	5 (10.4%)	7 (14.6%)	10 (20.8%)	7 (14.6%)

1. Knowledge 2. Quality and productivity 3. Minimize cost 4. Timely completion
5. Safety performance

Source: Own data, 2018

4.2.4.10. Delivery system

Among the category of design build delivery system, the first higher scored system tried to address in this study is the pure Design Building (DB). As the result indicated in the table below from the entire participants 17 (35.4%) of them convinced that the relevancy of pure DB is very high, and 7(14.6%) high for the construction sector. But, 6 (12.5%) respondents said that it is very low and 4(8.3%) low applicability. Mutually, the study evaluate the respondents response for what purpose pure DB would be applicable; so, as most respondents, 14 (29.2%), response it is using for the transfer of new knowledge, 10 (20.8%) informed to complete the job on time, 9 (18.8%) said for the improvement of quality and productivity, 8 (16.7%) said to minimize cost and 7 (14.6%) thought to improve safety performance.

Moreover, 28 (57.4%) study participants convinced that turnkey DB is highly reliable in the construction industry, whereas, 9 (18.8%) study participants oppose against the above respondents opinion, so, they evaluate the turnkey design building have a low applicable level. Relatively, the participants evaluate the benefit of turnkey DB; so, as the 14(29.2%) respondents criteria of selection it use for the transfer of new knowledge, 8 (16.7%) to improve quality and productivity, 8 (16.7%) to minimize cost, 13 (27.1%) to complete the job on time and 5 (10.8%) helps to improve safety performance in the construction industry.

The other delivery system in this category is enhanced/innovated/bridge DB. Accordingly, 13 (27.1%) respondents convinced that innovated DB perceived very high, and 5 (10.8%) high effect on the construction sector. But, 11 (22.9%) study participants informed that this budget applicability is lower. When those respondents evaluate the success of innovated DB 13 (27.1%) of them said it is helpful for the improvement of new knowledge, 12 (25.0%) to complete the job on time, 11 (22.9%) improves quality and productivity, 7 (14.6%) minimize cost and 5 (10.4%) improves safety performance for the Ethiopian construction industry.

Under the category of construction management delivery system, the first higher scored system tried to address in the study is the Construction Management (CM) prime contracting system. As the result indicated out of the entire participants 15 (31.3%) of them convinced that CM prime contracting have a very high effect on the construction sector. Likewise, 8 (16.7%) other respondents highly support the above respondents opinion; whereas, 6 (12.5%) study participants informed that the level of this item applicability is below what they expected. Cooperatively, they evaluate the benefit of CM prime contracting; as their evaluation 16 (33.3%) respondents evaluated that it is helpful for improving the new knowledge, 9 (18.8%) improves quality and productivity, 8 (16.7%) minimize cost, 7 (14.6%) to complete the job on time and 6 (12.5%) said to improve the safety performance.

Regarding the CM agent delivery system points of view, the majority of the respondents, 20(41.7%), convinced that the agent seat in the higher delivery bases. In contrast, 4(8.3%) of the respondents evaluate the level is found in the very low applicability level. The success of CM as agent is also used, as 16 (33.3%) respondents evaluation, to improve the new knowledge, 12

(25.0%) improves quality and productivity, (20.8%) minimize cost, 5 (10.4%) to complete on time and 5(10.4%) improves safety performance in the construction industry.

CM at risk is the other delivery system those are chosen by 15 (31.3%) respondents at a very high level of applicability. Similarly, 7(14.6%) study participants highly support the above respondent argument; whilst, 9 (18.8%) respondents oppose the above study participant idea and said the level of applicability of this item is low. When they evaluate its success level, the majority of the respondents, 16 (33.3%), convinced that the construction management at risk helps to improve the new knowledge, and 10 (20.8%) other respondents informed obliged to improve.

Furthermore, from the category of Public Private Partnership (PPP) delivery system, BOT is also tried to address in this study. The majority of the study convinced that this item adequately relevant for construction industry, while, 10 (20.8%) respondents said it is highly applicable. Contrarily, 7 (14.6%) respondents said the level of applicability is very low and 4 (8.3%) other study participants evaluate the level is low. As the majority, 22(45.8%), respondents evaluate level of CM prime contracting and convinced improves the new knowledge, 10 (20.8%) improves quality and productivity, 9 (18.8%) minimize cost, 5 (10.4%) to complete the job on time, and 2(4.2%) improves safety performance.

According to the study reviled in the table below, 13 (27.1%) study participants convinced that PBC related PPP is less appropriate for the construction sector, whereas, 9 (18.8%) respondents arguing the above study participant's idea. Rather they said that the level of applicability is high. Regarding the success 20 (41.7%) respondents informed that this PPP would help to improve the new knowledge, 12 (25.0%) improves quality and productivity, 10 (20.8%) minimize cost, 3 (6.3%) to complete their job on time and 3 (6.3%) improves safety performance in the construction industry.

Table 4.14: Project delivery system

Project Delivery System	Efficiency					Selection criteria (Success/ benefit related factors)				
	Very Low	**Low**	**Adequate**	**High**	**Very High**	**1**	**2**	**3**	**4**	**5**
DB(Design build) Related Delivery system										
Pure DB	6 (12.5%)	4 (8.3%)	14 (29.2%)	7 (14.6%)	17 (35.4%)	14 (29.2%)	9 (18.8%)	8 (16.7%)	10 (20.8%)	7 (14.6%)
Enhanced /innovated/bridge DB	7 (14.6%)	4 (8.3%)	19 (39.6%)	13 (27.1%)	5 (10.4%)	13 (27.1%)	11 (22.9%)	7 (14.6%)	12 (25.0%)	5 (10.4%)
Turnkey DB	7 (14.6%)	2 (4.2%)	11 (22.9%)	20 (41.7%)	8 (16.7%)	14 (29.2%)	8 (16.7%)	8 (16.7%)	13 (27.1%)	5 (10.4%)
CM(construction management) Related Delivery system										
CM as Agent/ free	4 (8.3%)	0 (0%)	24 (50.0%)	7 (14.6%)	13 (27.1%)	16 (33.3%)	12 (25.0%)	10 (20.8%)	5 (10.4%)	5 (10.4%)
CM at Risk	6 (12.5%)	3 (6.3%)	17 (35.4%)	7 (14.6%)	15 (31.3%)	16 (33.3%)	10 (20.8%)	7 (14.6%)	6 (12.5%)	9 (18.8%
CM Prime contracting	4 (8.3%)	2 (4.2%)	19 (39.6%)	8 (16.7%)	15 (31.3%)	16 (33.3%)	9 (18.8%)	8 (16.7%)	7 (14.6%)	6 (12.5%
PPP (Public private Partnership) Related Delivery system										
BOT related PPP	7 (14.6%)	4 (8.3%)	27 (56.3%)	5 (10.4%)	5 (10.4%)	22 (45.8%)	10 (20.8%)	9 (18.8%)	5 (10.4%)	2 (4.2%)
PBC related PPP	8 (16.7%)	5 (10.4%)	26 (54.2%)	2 (4.2%)	7 (14.6%)	20 (41.7%)	12 (25.0%)	10 (20.8%)	3 (6.3%)	3 (6.3%)

1. Knowledge 2. Quality and productivity 3. Minimize cost 4.Timely completion 5. Safety performance

Source: Own data, 2018

4.2.5. Popular international CTT models

Table 4.14 below is also indicated that the items of previous construction technology transfer model on the newly and improved model. It is one of the factors that capable to affect the technology transfer model. Accordingly the result in the table show the entire items average scores are higher than the median threshold (3) with lower standard deviation. So, the majority of the respondents positively support the indicated attritions.

The first higher scored prototype tried to address in this study is the needs and technology assessment model. As the result indicated in the table below, out of the entire participants 27 (57.2%) respondents convinced that the need and technology assessment mode is highly implemented and effective in most construction industries in Ethiopia. In contrast, only 1 (2.1%) respondent opposed the above opponents' idea. As this person opinion this model is least effective. However, the remaining 20 (41.7%) respondents informed that this model adequately operational in the construction sector. In fact, as per the majority of the respondent opinion, Mulder and Kassahun Yimer (2008) models are effective especially in the developing countries like Ethiopia construction industry.

Transferee Driven Technology Transfer Model is the second effective model chosen by the respondents next to Technology Acquisition/ Process Model. According to the study finding illustrated in the table below, the former model is highly effective said 17 (35.4%) respondents and 9 (18.8%) other respondent informed it is very highly effective. Similarly, 14 (29.2%) respondents said the later model is more effective and 11 (22.9%) other study participants it is most effective in the construction sector. This indicates more than half of the respondents convinced these models were common for the country construction technology.

The lower ranked models which are recommended by most respondents shown in the Table 4.14. According to the study finding 13 (27.1%) said high and 7 (14.6%) said the effect of the indicated models are very highly effectiveness.

Table 4.15: Popular international TT model

Popular model	**Level of Perception**						
	Very Low	**Low**	**Adequate**	**High**	**Very High**	**Mean**	**Std. deviation**
Needs and Technology Assessment (Mulder and Kassahun Yimer, 2008)	0 (0.0%)	1 (2.1%)	20 (41.7%)	17 (35.4%)	10 (20.8%)	3.75	0.81
TT Life Cycle based intra-firm Model (Malik)	0 (0.0%)	6 (12.5%)	24 (50.0%)	12 (25.0%)	6 (12.5%)	3.38	0.87
Comparative Marketing TT Model (Clantone *et al*)	1 (2.1%)	1 (2.1%)	26 (54.2%)	13 (27.1%)	7 (14.6%)	3.50	0.81
Technology Acquisition / Process Model (Simkoko)	0 (0.0%)	2 (4.2%)	21 (43.8%)	14 (29.2%)	11 (22.9%)	3.71	0.87
Source to Destination Movement based CTT model (Wang et al)	0 (0.0%)	4 (8.3%)	27 (56.3%)	10 (20.8%)	7 (14.6%)	3.42	0.85
Transferor <-> Transferee for Technology Transfer Model (Lin & Berg TT)	1 (2.1%)	3 (6.3%)	21 (43.8%)	13 (27.1%)	10 (20.8%)	3.58	0.96
Value Added TT Model (Wrookun)	0 (0.0%)	4 (8.3%)	20 (41.7%)	17 (35.4%)	7 (14.6%)	3.56	0.85
Human Centric /Dual TT Model (Al-Khazarji)	2 (4.2%)	1 (2.1%)	26 (54.2%)	13 (27.1%)	6 (12.5%)	3.42	0.90
Transferee Driven Technology Transfer Model (Wubishet Jekale)	0 (0.0%)	0 (0.0%)	22 (45.8%)	17 (35.4%)	9 (18.8%)	3.73	0.77

Source: Own data, 2018

4.2.6. Construction technology transfer process

The first higher scored CTT process stage tried to address in this study is the need assessment or problem identification, because it’s average 4.29 (SD±1.09) is larger than all over the remaining technology processes. Accordingly, 31 (64.6%) respondents convinced that the need assessment process stage get a very high perception level. Similarly, 4 (8.4%) study participants highly support the above respondents opinion, whereas, overwhelming, 2 (4.2%), respondents informed that the level of applicability of this stage is very low. This indicates that as most respondents believe problem identification took the first priority in the process stage of TT.

The next high ranked item is the impact of construction technology outcome determination in the transfer stage with the mean score of 4.27 and standard deviation 1.125. As 29 (60.4%) respondents believe this process is very highly relevant in the construction sector. Moreover, 10 (20.8%) respondents highly suppose the above study participants argument; however, 5 (10.5%) respondents confirmed that the effect of outcome determination level is low. This illustrated that more than ¾ of the study participants believe that construction technology outcome determination is a prior stage for the technology transfer process.

The third highest ranked stage in the process is construction technology transfer implementation with a mean score of 4.08 and standard deviation 1.088. Basically, 36 (75.0%) respondents highly support this technology process is essential for the construction; whilst, 4 (8.4%) respondents give a least priority for the subject. This implies that more than ¾ of the respondents believe that construction technology transfer implementation needed to be identified for the transfer process.

Construction technology transferee selection is the fourth ranked stage in the technology transfer process with the mean score of 4.00 and standard deviation 0.968. As far as the most respondents, 36 (75.0%), response the transferee selection stage took higher priority in the construction sector. In contrast, as per the 2 (4.2%) respondents’ consideration this stage took in the lower level.

Construction technology transfer testing or piloting is ranked in the fifth stage with the average score of 3.96 and standard deviation 1.01. Of course, in this case also most of the respondents 35 (72.9%) confirmed that the transfer testing seat in a higher level. But, 3 (6.3%) study participants oppose against the above respondents argument.

More over construction technology transferee demand is ranked in six levels having with a mean of 3.85 and standard deviation 1.091. About, 18 (37.5%) respondents said the transferee demand is very highly and 10 (20.8%) study participants highly relevant process stage in the construction sector. However, 3 (6.3%) study participants give a least priority for this stage.

In the seven place the respondent seat construction technology priority determination. According to the majority of the participants, 31 (64.6%), opinion this stage is highly relevant priory level, while, 5 (10.5%) respondents evaluate this stage is below what the above respondents expectation.

The respondent suggests that construction modes selection is the next stage of TT process with a mean score of 3.58 and standard deviation 1.182. According to the respondents level of priority, this mode of selection, 21 (43.8%) participants said high, and 10 (20.8%) informed very high relevance in the construction sector, whereas, 9 (18.7%) study participants gave a lower priority for this mode of selection.

The last rank of the technology transfer process is construction technology partner selection with a mean score of 3.44 and standard deviation 0.965. Basically, 21 (43.8%) respondents still chose this stage is highly applicable in the technology transfer process. Though 5 (10.5%) respondents oppose the above study participants' argument rather this stage should get a least priority.

Table 4.16: Technology transfer process

Technology transfer process	Level of Perception						
	Very Low	Low	Adequate	High	Very High	Mean	Std. deviation
Need assessment (problem identification)	2 (4.2%)	0 (0%)	11 (22.9%)	4 (8.3%)	31 (64.6%)	4.29	1.091
Construction technology transferee selection	2 (4.2%)	0 (0%)	10 (20.8%)	20 (41.7%)	16 (33.3%)	4.00	0.968
Construction technology transferee demand determination	2 (4.2%)	1 (2.1%)	17 (35.4%)	10 (20.8%)	18 (37.5%)	3.85	1.091
Construction technology priority determination	2 (4.2%)	3 (6.3%)	12 (25.0%)	19 (39.6%)	12 (25.0%)	3.75	1.042
Construction technology partner selection	2 (4.2%)	3 (6.3%)	22 (45.8%)	14 (29.2%)	7 (14.6%)	3.44	0.965
Construction modes selection	4 (8.3%)	5 (10.4%)	8 (16.7%)	21 (43.8%)	10 (20.8%)	3.58	1.182
Construction technology transfer testing/piloting	2 (4.2%)	1 (2.1%)	10 (20.8%)	19 (39.6%)	16 (33.3%)	3.96	1.01
Construction technology transfer implementation	2 (4.2%)	2 (4.2%)	8 (16.7%)	14 (29.2%)	22 (45.8%)	4.08	1.088
Construction technology outcome determination	2 (4.2%)	3 (6.3%)	4 (8.3%)	10 (20.8%)	29 (60.4%)	4.27	1.125

Source: Own data, 2018

4.2.7. Construction technology transfer channels

As indicated in the tables below, the mean score of the responses perception levels of the entire items are above the median threshold (3). In that regards, the majority of the study participants average perception level skewed into the highest perception level. Moreover, the variations also do not much deviated from the average, so, there is no strong disparity among the respondents perception.

Furthermore, each channel items are explored further with relation to construction transfer technology. The indicators were given and the respondents were asked to pick from a likert-scale ranging from ‘very low to very high’.

So, as a result illustrated, the first higher scored channel tried to address in this study is the university-industry linkage with mean 4.13 and standard deviation 1.299. Explicitly, out of the entire participants 28 (58.3%) of them convinced that university-industry linkage channel is very highly implemented and effective in most construction industries in Ethiopia, similarly, 9 (18.8%) study participants support these respondents argument. In contrast, according to the 4 (8.3%) study participant opinion this channel is least effective and 3 (6.3%) others support their belief. In fact, more than ¾ of the respondent convinced that the university–industry linkage is effective especially for the Ethiopian construction industry.

The second higher scored channel tried to address in this study is training with a mean score of 4.08 and standard deviation 1.334. From the entire participants 27 (56.3%) of them convinced that training channel is very highly implemented and effective, likewise, 10 (20.8%) respondents informed that the channel is greatly adequate in most construction industries in Ethiopia. Quite the reverse, 5 (10.4%) respondents confirmed that the effect is very low and 2 (4.2%) others said it is low; i.e., this channel is least effective. This illustrated that as most respondents believe the construction sector training is efficient for the transfer of technology.

The third higher scorer channel in this study is the best/ proven practices with a mean score of 3.98 and standard deviation 1.101. In more detail, according to the 19 (39.6%) respondents belief best or proven practices channel is very highly and 15 (31.3%) other highly implemented and effective in most construction industries in Ethiopia. In contrast, 11 (22.9%) study participants convinced that the effect is low and 3 (6.3%) other respondents said the effect is very low. However, the remaining 15 (31.3%) respondents informed that this channel is adequately operational in the construction sector. This implies, as most respondents' opinion the best or a proven practice is efficient method for the CTT industry in Ethiopia.

The next higher scored channel covered in this study is the management, turnkey, and sub-contracts. According to the reviled result 21 (43.8%) respondents highly and 13 (27.1%) very highly management, turnkey, and sub-contracts channels are implemented and effective in most construction industries in the country; whereas, as 5 (10.4%) respondents opinion these channels is least effective. However, the remaining 9 (18.8%) respondents informed that this channel is adequately effective. Likewise, the import substitution is highly effective channel said 19 (39.6%) respondents, similarly, 14 (29.2%) study participants support those opponents idea; whilst, 6 (12.5%) respondents oppose this idea rather they arguing the import substitution is least effective channel in the construction sector. In summing up as the vast respondents believe the construction sector management, turnkey, and sub-contracts as well as import substitutions are efficient and practiced method of TT for the Ethiopian construction industry.

The fifth higher scored channel covered in this study is the joint ventures effect with a mean score of 3.65 and standard deviation 1.101. Accordingly, 19(39.6%) respondents informed that this channel is highly adequate and operational in the construction sector, correspondingly 11 (22.9%) of the study participants convinced that joint ventures is very highly implemented and effective channel in most construction industries in Ethiopia. In other way round 6 (12.5%) respondents said it is less effective, and 2 (4.2%) other respondents said the effect is very low. As those respondents opinion this channel is least effective. However, the remaining 10(20.8%) respondents informed that this channel is adequately effective. This implies, as more than half of the respondents opinion the joint ventures effect is a nice effect for the TT for the Ethiopian construction industry.

On the six ranking order respondents puts licensing, franchising, patents, trade mark, branding agreements channels with mean 3.56 and standard deviation 1.129. Based on the result illustrated 14 (29.2%) respondents informed that this channel is highly adequate, equally 13 (27.1%) study participants said it is very highly implemented and effective channel in most construction industries in country; whereas, 10 (20.9%) of the respondents oppose against the above opponents' idea. As those respondents opinion this channel is least effective. However, the remaining 11 (22.9%) respondents informed that this channel is adequate in the sector. Still, this result indicates this channel is effective and importance for the construction sector.

About 30 (62.5%) respondents convinced that imitations or reverse engineering is highly adequate channels in the construction sector. On the other hand, 9 (18.8%) respondents pursued that the effect is low; i.e., as their opinion this channel is least effective. However, the remaining 9 (18.8%) respondents informed that this channel is adequate. This indicates as most of the respondents' belief the channel is adequate for the TT process.

The least effects are foreign minority holding with mean 3.27 and standard deviation 1.198, fading out agreements/ direct purchase of capital goods having a mean score of 3.23 and standard deviation 1.016 and foreign subsidiary (FDI) with mean 3.21 and standard deviation 1.051. According to order of the mean score levels respondents put them on the bottom as a channel for the Ethiopian construction industry. Even if the effect is least effective as most respondents opinion, more than ½ of the study participants still convinced that those channels are adequate for the construction industry. This implies that those channels are adequate bet less practical.

Table 4.17: Construction technology transfer channels

Construction technology transfer channels	**Level of Perception**						
	Very Low	**Low**	**Adequate**	**High**	**Very High**	**Mean**	**Std. deviation**
Foreign Direct Investment (FDI)	2 (4.2%)	10 (20.8%)	18 (37.5%)	12 (25.0%)	6 (12.5%)	3.21	1.051
Joint Ventures	2 (4.2%)	6 (12.5)	10 (20.8%)	19 (39.6%)	11 (22.9%)	3.65	1.101
Foreign Minority Holding	6 (12.5%)	3 (6.3%)	19 (39.6%)	12 (25.0%)	8 (16.7%)	3.27	1.198
Fading Out Agreements / Direct Purchase of Capital Goods	2 (4.2%)	8 (16.7%)	21 (43.8%)	11 (22.9%)	6 (12.5%)	3.23	1.016
Licensing, Franchising, Patents, Trade Mark, Branding Agreements	3 (6.3%)	7 (14.6%)	11 (22.9%)	14 (29.2%)	13 (27.1%)	3.56	1.219
Management, Turnkey, and Sub Contracts	5 (10.4%)	0 (0%)	9 (18.8%)	21 (43.8%)	13 (27.1%)	3.77	1.171
Training	5 (10.4%)	2 (4.2%)	4 (8.3%)	10 (20.8%)	27 (56.3%)	4.08	1.334
Import Substitution	4 (8.3%)	2 (4.2%)	9 (18.8%)	19 (39.6%)	14 (29.2%)	3.77	1.171
Imitations (Reverse Engineering)	3 (6.3%)	6 (12.5%)	9 (18.8%)	22 (45.8%)	8 (16.7%)	3.54	1.110
Best / Proven Practices	3 (6.3%)	11 (22.9%)	15 (31.3%)	15 (31.3%)	19 (39.6%)	3.98	1.101
University Industry Linkages	4 (8.3%)	3 (6.3%)	4 (8.3%)	9 (18.8%)	28 (58.3%)	4.13	1.299

Source: Own data, 2018

4.2.8. Construction technology transfer conducive environment

The respondent was requested to rank the effect of creating conducive environment for concerned with the success or effectiveness of transfer of construction technology. For the construction technology transfer to create conducive environment transferee characteristics, transferor characteristics, relationship building and transfer environment play a vital role. The scale was rated with a 5 point Likert scale inquires ranges from (1) very low, (2) low, (3) adequate, (4) high and (5) very high. As indicated in the tables below, the mean value of the responses perception levels of the entire items are above the median threshold (3).

The below table illustrated the overall average and standard deviations of respondents perception towards transferee characteristic on the construction technology. According to this study finding the average level of perception of the respondents on the transferee characteristic was 4.13 and standard deviation 0.914. The mean result indicate that the identified items such as transferee readiness, knowledge base, transferee management practice, transferee degree of experience in the transferee characteristics were perceived to have significant impact on the technology transfer process. The standard deviation was gain low indicating that all had similar opinions.

Moreover, as per the majority respondents believe, the construction technology have been perceived a significant impact, because, the average perception level of the respondents 3.96 (SD±0.893) lay above the median threshold. The mean result indicate that the items which identifies like transferor willingness, knowledge base, transferor management practice, and transferor degree of experience in the transferor characteristics were perceived to have significant impact on the technology transfer process. In fact the mean deviation from the individual observations was gain low indicating that all had similar perspective about the variables on the study.

The average mean score of relationship building or learning environment effect was 3.89 with a standard deviation of 0.911. The score result illustrated that the indicated items of culture, trust, understanding and communication between transferee and transferors in the relationship building were perceived to have significant impact on the technology transfer process with low standard deviation which indicating that all the items had similar standpoints about the variable or the issued domain.

Mine while, the mean value of transfer environment for technology was 3.72 with a standard deviation 0.901. This indicated that the listed items such as economic level of the country, government enforcement of technology transfer (TT), clear government policy, mode of transfer, technology complexity, physical infrastructure, finance, information, skill development and technology brokering (Supportive institution), mechanism for intellectual property right, tax holidays, tariff adjustments and industry parks related legislation and incentives, implementing efficiency at various level of government (Bureaucracy), tax policy effectiveness, and foreign currency stability in the transfer environment were supposed to have significant impact on the technology transfer process. The standard deviation was gain low indicating that all had similar standpoints about the variables.

Due to high mean important ranking the variables were identified as important in describing TT process by the majority of respondents and should be considered important factors in developing and accurate prediction model for CTT in Ethiopian construction works.

Table 4.18: Creating conducive environment for technology transfer

Conducive environment	Statistics		
	N	Mean	Std. deviation
Transferee characteristic	48	4.13	0.914
Transferor characteristic	48	3.96	0.893
Relationship building or leaning environment	48	3.89	0.911
Transfer environment	48	3.72	0.901

Source: Own data, 2018

4.3. Construction technology and transfer mode for the Ethiopian construction industry

4.3.1. Problem encountered in the regression model

The previous section told about the descriptive result of the construction technology transfer. To identify the types of construction technology and technology transfer mode this can be applicable for the construction industry, herein, the study considers a multiple linear regression. The researcher primarily categorizes the dependent variable into Likert scale form. That is, the data was collected through questionnaire which measured using 5-point Likert ranging from 1=very low to 5=very high. A similar approach is also used when coding the independent variables. The correlation and the regression test statistics is carried out by taking into the consideration of the basic research questions for assessing the relative effect of the explanatory variables over the dependent.

The study has examined various causal factors which are assumed to have effect on the selection criteria of the new construction technology transfer. In the model, the study tried to incorporate factors such as new construction technology (X_{1i}), effectiveness of popular construction technology transfer mode (X_{2i}), the technology transfer process (x_{3i}), technology transfer channel (x_{4i}) and conducive environment (x_{5i}). To avoid an excessive number of variability and unstable estimates in the subsequent model, only variables that have reached a p-value less than 0.05 are taken into consideration in the subsequent analyses.

According to the correlation analysis result of this study, all the independent factors are linearly associated with the dependent variable, selection criteria, the except effectiveness of popular construction technology transfer mode as shown in the table below (Table 4.19). That is, as the outcome elaborates, the new construction technology, the technology transfer process, technology transfer channel and conducive environment have a significant association with selection criteria (sig. <0.05).

Table 4.19: The correlations matrix among dependent and independent variables

		Y_i	X_{1i}	X_{2i}	X_{3i}	X_{4i}	x_{5i}
Selection criteria (Y_i)	Pearson Correlation	1	0.360*	0.228	0.249*	0.369*	0.390*
	Sig. (2-tailed)		0.012	0.119	0.027	0.040	0.022
New technology (X_{1i})	Pearson Correlation		1	0.323*	0.417*	0.385**	0.578**
	Sig. (2-tailed)			0.025	0.003	0.007	0.000
Popular model (X_{2i})	Pearson Correlation			1	0.317*	0.128*	0.382**
	Sig. (2-tailed)				0.028	0.386	0.007
Transfer process (X_{3i})	Pearson Correlation				1	0.562**	0.701**
Channels (X_{4i})	Sig. (2-tailed)					0.000	0.000
	Pearson Correlation					1	0.751**
	Sig. (2-tailed)						0.000
Conducive environment (x_{5i})	Pearson Correlation						1
	Sig. (2-tailed)						

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

Source: survey data, 2018

The next step is running multiple liner regression analyses based on the selected independent variables. For the regressing of these variables, the researcher has used enter method, which is the default procedure available in SPSS. It is used hierarchically to assess the relative effect of those variables that have significant relationship with the outcome variable which in this case is selection criteria.

Primarily, all the above analyses have been dealt with the existence of outliers, multicollinarity among independent variables, and heteroscedasticity were checked through Cook's distance, Variance Inflation Factor (VIF), and graphical representation under the consideration of standardized predicted variable verse standardized residual. As the result indicated, the minimum Cook's result is zero while the maximum is 0.779. These figures indicate the value is less than one. So, it is not detected any outliers which affect the model. Likewise, multicollinarity problem is not presented in the model because of the value of VIF of all the case lies between (1.286, 4.051), i.e., less than 10. Thus, there is evidence that multicollinarity, strong relationship among explanatory variables, is not a serious problem for the formulated model. When the error term varied with the independent variables, the problem of Heteroscedasticity would occur. This is tested by drawing a graph with standardized predicted versus standardized residual curve. In the curve if any continuity trend observe, i.e., if the standardize perception distribution show an increment or decrement trend over the standardized residual, the problem of Heteroscedasticity is detected otherwise it is safe from the problem. In that regard, the distribution of the data did not show any such kinds of trend rather they are going in a constant pattern within a specified interval (2, -2); hence, the Heteroscedasticity problem is not obvious. For more information, look at Appendix *E*.

4.3.2. Construction technology transfer mode

Regression analysis was conducted to examine the causal and strengthens of a relationships between the dependent and independent variables. A regression model was formulated and tested to understand by how much each independent variable: new construction technology (X_{1i}), effectiveness of popular construction technology transfer mode (X_{2i}), the technology transfer process (x_{3i}), technology transfer channel (x_{4i}) and conducive environment (x_{5i}).

Before giving analytical explanation based on the model, some additional diagnostic tests should be checked like, whether the model is fitted or not by using ANOVA. As the result illustrated in the table below, the F-test of the p-value is 0.005 and the significant value is 0.05. Hence, the significance (sig.) value is greater than that of the p-value; therefore, accept the statement which is stated that the model is fitted. Having this in mind, the next question which follows is how much is the model good. The answer is given by R square (R^2). This test measures how much of the variation in the dependent variable, selection criteria, identified by the regressors. The larger the value of R square, the better it fits.

In fact, Table 4.19 displays R square and adjusted R square with the standard error of R. R squared is ranged from 0 to 1. Small values indicate that the explainable level of the independent variables is weak to determine the dependent variable. The sample R squared tends to optimistically estimate how well the models fit for the population. Both R squared and adjusted R square somehow has the same meaning and purpose. But, adjusted R square is applicable for the small numbers of observation ($n<30$) and numbers of variables.

So, in the case of this study, the researcher used the R square, because the numbers of variables involved in the study are not few. Therefore, as the output illustrated the value of R square in this case was 0.218. This shows that 21.8% of the variation of selection criteria can be accounted by the confluence of the five independent variables.

The other expected misspecification problem can be handled by the t-test statistics. That is, the researcher checked whether all the independent factors are important to determine the model or not, by using t-test statistics. If the p-value is lesser than the sig value (0.05), the variable/s are important to determine the model otherwise they should be rejected them in the model. According to this study result all the independent variables except the popular construction technology transfer mode are important to determine the selection criteria/ benefit of technology transfer.

The sign of the beta coefficient, positive or negative, also shows the association either direct or inverse effect of the independent variables over the dependent once. From the result revealed in the table below, all the significant explanatory variables are positive. That means any increment or decrement in the independent variables lead to increase or decrease in the dependent counterpart.

Result of regression analysis presented in table below also provides more comprehensive and accurate examination of the research questions. Therefore, the regression analysis was used to test the developed questions based on the specific objectives and investigate the contributions of the independent variables to the dependent once.

Primarily, the researcher wants to check whether the new construction technology (X_{1i}) is statistically significant to determinant the selection criteria of new technology transfer (Y_i) or not. Hence, as the result indicated, X_{1i} is statistically significant associated with the dependent variable selection criteria (Beta= 0.223, p-value = 0.019 < sig. value = 0.05) because the P-value=0.019 is less than that of the sig. value= 0.05. Therefore, there is good evidence that the two variables associated to each other. This impels after taking the remaining effect as a constant, for a unit percentage change of new construction technology would lead 22.3% increment of the applicability of selection criteria of new construction technology transfer. The finding of this study result is the same as Wubishet Jekale (2017) study findings. The case study which is done with selected construction company was also elaborated the new construction technology on construction technology transfer as like:

> *…Concrete batching plant, asphalt batching plant, block and brick manufacturing, aluminum profile manufacturing, cutting and bending machine, applying DB; manufacture reinforced concrete pipe (RCP), crusher plant, waffle formwork system, BIM, culculex software and machinery practiced; the selectin criteria for the benefit of new technology are improve quality and productivity, minimize cost and minimize time the project…*

The study is also tests the effectiveness of popular construction technology transfer mode (X_{2i}) whether have an effect on the selection criteria or not. As the result shown, the P-value of the t-test statistics (0.909) is higher than the significant threshold (0.05). So, reject the statement which is assumed that the two variables associated to each other. Rather the popular model does not have an influence on the selection criteria of new technology transfer.

In other way round, the researcher wants to check whether the technology transfer process (x_{3i}) has significant contribution on selection criteria or not. As a result indicated ß = 0.054 P-value=0.037 < sig. value= 0.05, so, the significant value is lesser than the p-value. Thus, taking the remaining effect as a constant, for a unit percentage increment of the technology transfer process would lead 5.4% increment of the effectiveness of selection criteria. The finding of this study result is the same as Kebede and Mudler (2008) and Adikibi (1984; 2008) study findings. Likewise, the key informant participant suggested:

> *… Appropriate technology transfer stage is vital for the success of technology. But mostly, the current construction sector does not use any procedure, i.e., which comes first and which go next was not done by scientifically array system. Thus, for the effective technology transferring procedures training like UCBP and other simile programs should facilitate in the country…*

Technology transfer channel (x_{4i}) is also statistically determinant effect for the selection of new technology transfer criteria. Because, as the result illustrated in the below table the P-value of the t test statistics (0.008) is still lower than that of the sig. value (0.05). Therefore, there is enough evidence that for a unit percentage increment of technology transfer channels, the applicability of the selection criteria would escalate 38.3% after taking the other effect considered as a constant. For instance the case study which is done with selected construction company was also elaborated as:

> *…mostly the construction companies practice on training, subcontracting, joint venture, purchase of capital goods, working with foreign companies and professionals to transfer technology as mines of channels …*

Of course, the finding of this study result is the same as Wubishet Jekale (2017) and Calantone *et al*. (1990) study findings.

Meanwhile, the study also tried to test the conducive environment (x_{5i}) whether have an effect on success of selection criteria of a new construction technology or not. As the result shown, the P-value of the t- test statistics (0.011) is lower than the significant doorsill (0.05). So, accept the statement which is stated that creating conducive environment and applicability of technology transfer selection criteria have an association to each other. So, for a unit percentage change of the environment would lead to increase 45.4% change of effectiveness of selection criteria of the construction industry after taking the remaining effect as a constant. The finding of this study result is the same as Warookun (2007), Lin and Berg (2001) and Wubishet Jekale (2017) study findings. The case study which is done with four construction companies also elaborated as:

> *…the conducive environments plays important roll on the technology transfer in the relationship building language and working culture are considered as a barrier. The economic level of the country, rules and regulations related to technology transfer, the foreign currency issues are affected the transfer. The technology receiver readiness and the company owners' commitment to adopt new technology is crucial for effective transfer of technology.…*

Table 4.20: Regression Model Summary

Source	SS	Df	MS		
				F(5, 42)	= 2.345
Model	6.524	5	1.305	Prob > F	= 0.005
Residual	23.375	42	0.557	R-squared	= 0.218
				Adj R-squared	= 0.125
Total	29.899	47		Root MSE	= 0.746

Number of obs = 48

Variables	Coef.	Std. Err.	t	P>t	[Beta]
New technology (X_{1i})	0.264	0.200	1.318	0.019*	0.223
Popular model (X_{2i})	0.024	0.205	0.115	0.909	0.018
Transfer process (X_{3i})	0.052	0.185	0.283	0.037*	0.054
Channels (X_{4i})	0.348	0.196	1.779	0.008*	0.383
Conducive environment (X_{5i})	0.446	0.257	1.619	0.011*	0.454
_cons	2.381	0.792	3.005	0.040*	

Dependent variable: Selection criteria (Y_i)
* Regression is significant at the 0.05 level (2-tailed).
Source: survey data, 2018

4.4. Construction technology transfer model for the Ethiopia construction industry

Based on the four sets of domains that identified in the research, the expected model had been developed as shown in the figure below. The association between the variables are made from Pearson Correlation coefficient. The sequence of the variables are developed based on standardized beta value the variables with higher value comes on the top and variables with lower value on the bottom. Each of the domains constructed with various items. These are:

Item 1: Creating conducive environment: This domain caries the following list of items

- **Transferee characteristics:** are included transferee readiness, knowledge level of the transferee, transferee management practice, and transferee degree of experience.
- **Transferor characteristics:** containing transferor willingness, knowledge level the transferor, transferor management practice, and transferor degree of experience

- **Relationship building/ learning environment**: elements of relationship building are culture difference between transferee and transferor, trust between transferee and transferor, understanding between transferee and transferor, communication between transferee and transferor.
- **Transfer environment:** under the category of transfer environment economic level of the country, government enforcement of technology transfer (TT) like rules and regulations, clear government policy such as science and technology policy, mode of transfer like joint venture, foreign direct investment (FDI), turnkey etc., technology complexity, physical infrastructure including road, water, and electricity, finance, information, skill development and technology brokering, mechanism for intellectual property right, tax holidays, tariff adjustments and industry parks related legislation and incentives, implementing efficiency at various level of government (bureaucracy), tax policy effectiveness, and foreign currency stability

Item 2: Channel determination:

Some of the channels practiced internationally are foreign direct investment (FDI)**,** joint ventures, foreign minority holding, fading out agreements/ direct purchase of capital goods**,** licensing, franchising, patents, trade mark, branding agreements**,** management, turnkey, and sub contracts**,** training**,** import substitution**,** imitations or reverse engineering**,** best proven practices and university industry linkages.

Item 3: New technology classification: can be explained by:

- **Earth work**: some of the technologies under this category are spider excavators, mini excavators, articulated hauler, and tunnel boring machine.
- **Floors walls and slabs**: it includes pre-fabricated and assembly system, pre-cast system, bubble deck slab flooring, ezyprofile-slab profiling tool, and self-cleaning glass windows.
- **Temporary structures**: The new technologies in temporary structures are steel panel modular formwork, aluminum formwork system, plastic formwork systems and movable formwork.
- **Reinforcement**: can be include mesh bending and cutting machine, mesh welding machine, shaping centers, reinforcement bar coupler, and automatic rebar tying machine.

- **Concrete works**: it carries concrete pumps, cast-in-place booms, fiber reinforced concrete, admixture chemicals, and automatic concrete screening machine.
- **Block masonry**: movable and stationary block making machine and mobile mortar mixer
- **Finishing works**: these technologies holding plastering machine, glass tiles and airless spray painting machine.
- **Water proofing materials**: masonry water proofer and damp proofing cream used for waterproof layer applied into base wall.
- **Information and communication technology**: It is taking the following items into account: 3D hand held computers, 3D printing, building information modeling, ground penetrating radar systems for civil works, spectra precision laser scanning, and e-business technologies for procurement.
- **Delivery system**: this includes design build related delivery system such as pure DB, enhanced/novated/bridge DB, turnkey DB; construction management related delivery system like CM as agent/ free, CM at risk and CM Prime contracting; public private partnership related delivery system including BOT and PBC.

Item 4: TT process phases: under this particular effect, the following items can be included:

1. **Need assessment:** Needs have to be identified, and the basic characteristics of the needs in terms of quantity, price levels, and cultural preconditions. This involves identifying the needs of the receiving society.
2. **Construction technology transferee selection**: transferee in the Ethiopian construction industry are: construction organizations which contains Ministry of Construction, Regional Construction Bureau, Urban Construction Bureau, Building Contractors, Highway Contractors, Railway Contractors, Water Works Contractors, General Contractors, CM Consultants, sub-contractors such as consultants, machineries rental companies, major material suppliers, testing organizations and civil societies including CI associations. Moreover, professional communities like architects, engineers, COTM professionals, urban management professionals, surveyors, forman, trade works occupational, equipment operators, laboratory technicians.

3. **Construction technology transferee demand determination**: it determine the demand of technology transfer defined based on quality, time, cost, input, process, method and enhanced health and safety.
4. **Construction technology demand priority**: which determine the transferee critical failure factors priorities, CTT with respect to cost, time, quality, safety, etc., methods priorities, inputs priorities and processes priorities
5. **Construction technology partner selection**: for this should be considered the transferor willingness, knowledge level of the transferor, transferor management practice, and transferor degree of experience.
6. **Construction technology transfer modes selection**: the activities done in this stage are CT selection, transferor selection, CTT process definition, CTT model definition, CTT channel definition, CTT effectiveness and VA indicators, and CTT program development
7. **Construction technology transfer testing/piloting**: in this stage the selected technology developed and tested on the field to check its applicability.
8. **Construction technology transfer implementation**: activities performed in this stage are transferee absorptive capacity, transferee experience in TT, transferee commitment and trust for TT, transferee cultural and language situation, transferor knowledge base, transferor experience in TT, transferor willingness, transferor local knowledge, transferor involvement of Diaspora as KTI and BCBLTE and transfer planning, and mutual understanding and commitment.
9. **Construction technology outcome determination**: once the whole transfer process is done, measuring the success or failure of the transfer process helps to learn from mistakes and leads to improving the next transfer processes.

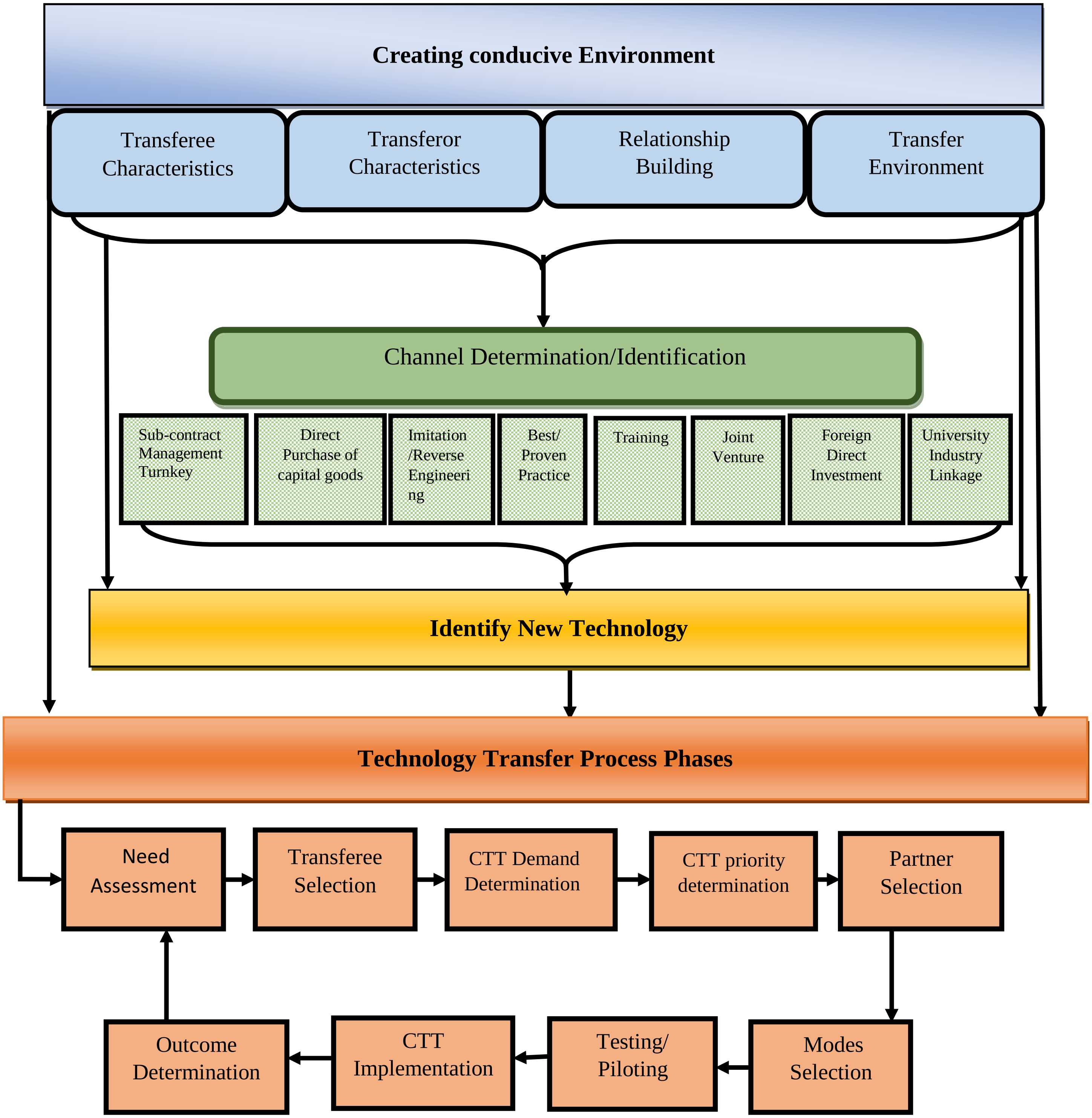

Fig 4.1: Enhanced CTT model for Ethiopian construction Industry

The appropriate model for the Ethiopian construction industry is the enhanced CTT model. The model is developed based on the empirical review of related literature, results of descriptive and inferential analysis. Basically, this model is lined with Wubishet Jekale (2017) and Warookun (2007) models. The Wubishet (2017) model focused on the conducive environment and technology transfer process phases by reviewing related research and using worldwide TT experience. Whereas, Warookun (2007) model focused on only the conducive environment and outcome determination/TT value added of the technology transfer process. Unlike with their dimension this study included the domains such as creating conducive environment, channel determination, identification of new technology, and technology transfer process.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The local construction firms in Ethiopia are still characterized by small; there are lack of capacity and capability too, in delivering project on time, with budget and expected quality. Furthermore, the result of the survey, key informant interview and case study demonstrate that the level of technology transfer practice in the construction industry is very low and fragmented. From the total of grade one general contractor there is also a big technology practice gap among the industries.

The top selected improved technologies in the earth work of construction are mini excavator and spider excavator; likewise, in the case of floors, walls and slabs technologies such as pre-fabricated and assembly system, and bubble deck slab flooring. For the formworks like steel panel modular formwork and movable formworks are commonly used. Moreover, for the case of reinforcement works most contractors use a technology like mesh bending and cutting machine, reinforcement bar coupler and automatic rebar tying machine. The contractors also employed concrete pumps and admixture chemicals for the concrete works. In the case of block masonry works, movable or stationary block making machine and mobile mortar mixer had been more practiced. In favor of the finishing works technologies like plastering machine and airless spray painting machine had usually been implemented. Intended for waterproofing works the damp proofing cream and masonry water proofer machineries were commonly used. Besides, in the case of information and communication technology: the e-business technology, building information modeling, and 3D printing technologies practice in more; while, under the alternative project delivery system pure design building, construction management prime contracting and build operate transfer are the top selected construction technologies commonly exploited by the study participants.

The benefit of the improved technology is evaluated by five measurement criteria such as improved knowledge and working practice, improved quality and productivity, minimize cost, timely completion, and improved safety performance. Besides, there is poor performance in knowing, owning and adopting the new technology for construction sector in Ethiopia. Because, some of the contractors never participated in the technology transfer practice. Second, even the contractors use the improved technology, the majority of the contractors those alien and working in the same sector did not use the same technology at the same time, i.e., there is a great variations of new technology utility among contractors.

The most practiced technology transfer channels that usually exercised by the Ethiopian contractors are university-industry linkage, training, best or proven practices, management, turnkey, and sub-contracts and import substitution. Likewise, the need assessment or problem identification, outcome determination, construction technology transfer implementation, construction technology transferee selection and construction technology transfer testing or piloting are the top five technology transfer process stages.

The study initially stated research question that tried to investigate factors like creating conducive environment, construction transfer channels, identification of new technology, technology transfer process, and effectiveness of popular construction technology transfer model on selection criteria for the benefit of technology transfer. Yet, the entire facers contributed to the selection criteria except the effectiveness of popular model; whereas, the remaining factors contribute more for the success and benefit of technology transfer selection criteria.

Based on the basic factors that affect the selection criteria of new technology, CTT model was developed. The model used as a guide to facilitate the technology transfer process and improve the productivity of the construction industry of the country.

5.2. Recommendation

Based on the above conclusion the researcher forward the following recommendation for the concerned bodies:

- In fact, the construction industry of Ethiopia is poor to accomplish the project on time, budget and quality. To address the problem government and local construction firm should invest fund for transferring a new technology which capable to reduce working burden.
- The study provides evidence that the government must set a list of standardized requirement and obligations on which the foreign companies and contractors follow to transfer the technology for local firms such as the amount for sub-contract to local firm, numbers and type of local workers participate on project.
- Creating conducive environment for the technology transfer is a crucial step for the successful movement of technology. So, both the government and the construction company give focus on facilitating the environment.

5.3. Recommendation for further study

This study with its limitation has investigated construction technology transfer for the construction work on grade one contractors. Nevertheless, the following issues are identified and suggested for future studies.

- Further investigation on construction technology transfer on other construction firms and consulting companies.
- Study on feasibility of construction technology transfer channels on improving the Ethiopian construction industry.
- Developing TT performance measurement framework and associated method for benchmarking.

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APPENDIX

Appendix A

Questionnaire

For construction Professional

Construction technology transfer for the Ethiopian construction works: The cases of grade one contractors

I am presently pursing a Master of Science Degree in college of Architectural and Civil Engineering under construction Technology & Management Engineering stream at Addis Ababa Science and Technology University.

Dear respondent, the aim of this questionnaire is to study ***Construction technology transfer for the Ethiopian construction works***. Therefore, you are kindly requested to contribute to this research work by completing this questionnaire. All the information gathered will be kept confidential and will be used only for academic purpose and analysis without mentioning the names of individuals and companies involved. The respondent who fill this questionnaire should be Managers who have experience in CTT. I would like to extend my gratitude for taking your precious time to respond to this questionnaire.

If you have any inquiry please contact through the following addresses.

Yeshialem Zelalem

Post Graduate Student at Addis Ababa Science and Technology University, college of architecture and Civil Engineering, Construction technology and management stream.

Email: yzbird2000@gmail.com

PREFACE

Popular technology transfer models

This research examines some of the popular models of technology transferor that have been developed over the years to help transferees and transferors of technology understand the technology transfer process better.

1. **TT Life Cycle based intra-firm Model (Malik) (the basic concept discussed are factors likely to help**, factors likely to inhibit, transmitter and receiver, Mode of transfer and feedback mode)
2. **Comparative Marketing TT Model** (**Clantone et al)** (describes five elements which are environment, actors, structure, process and function that influence the process and the relationship between them. the, project perspectives and client characteristics)
3. **Technology Acquisition / Process Model (Simkoko)** (the model identifies six elements which are alternative project delivery system, project management teams, technology transfer program, technologies and client characteristics)
4. **Source to destination movement based CTT model (Wang et al)** (the model identifies two stages first stage focused on capacity to transfer and willingness to transfer the second stage includes capacity to learn, Knowledge contributed by MNC and willingness to learn)
5. **Transferor Transferee for Technology Transfer Model (Lin & Berg TT)** (this model focused on cultural effects nature of technology transfer experience and technology transfer effectiveness)
6. **Value Added TT Model (Wrookun)** (taking three measures of outcomes Economy Advancement ,Knowledge / Technology Advancement and Project Performance and four enabling factors such as transferee characteristics, transferor characteristics, Relationship building and transfer environment)
7. **Human Centric /Dual TT Model (Al-Khazarji)** (Human Centric Technology Transfer taking Diasporas as Knowledge & Technology Integrators (KTI) and Bilingual, Bicultural and Technical Experts (BTT))
8. **Needs Assessment and Technology Assessment(Mulder and Kassahun Yimer) (**identifies crucial steps for technology transfer like needs assessment, technology assessment and identifies factors such as technical factors, economic factors, institutional factors and environmental factors
9. **Transferee driven Technology transfer Model (Wubishet Jekale)** (taking four principles such as transferee driven, continuous conducive CTT environment, continuous effective international and phased CTT development process and modified triple helix approaches)

Section 1: Demographic status of the respondent

101. Name of the respondent (optional) ________________________________

102. Name of organization (Optional) _________________________

103. Type of organization

1. Main Contractor 2. Sub-Contractor 3. Consultant 4. Other (please specify) ________________

104. Respondent years of experience in the construction industry_________________

105. How many projects have you been involved with where technology transfer (TT) was incorporated? _________________

Scale for ranking options: This ranking table is used for all questions below

1	**2**	**3**	**4**	**5**
Very Low	Low	Adequate	High	Very High
Highly inappropriate	Inappropriate	Satisfactory	Appropriate	Highly Appropriate

Section 2: Selection criteria of new technology (success/Benefit factors) for technology transfer

Rank the effectiveness of the selection criteria for the benefit of new technology (1,2,3,4,5)

Code	**Selection criteria(success/Benefit)related factors**	**1**	**2**	**3**	**4**	**5**
201	Improved knowledge and working practice (project management techniques, engineering and construction techniques, IT system)					
202	Improved quality and productivity (no rework, minimize wastage)					
203	Minimize cost overrun (minimize wastage beyond tolerance, minimize non compensable losses)					
204	Timely completion (no delivery delay, Minimize idleness)					
205	Improved safety performance (minimize accident)					
If others please specify and rank						

Section 3: Construction technology for transfer

Construction technology which enhances productivity, quality, and safety also minimize cost, time and waste. Based on your experience of construction technology transfer please rank the effectiveness for the Ethiopian construction work (1, 2, 3, 4, 5) and rank the success/ Benefit related factors for each technology from section 2 (201, 202, 203, 204, 205).

Code	Factors related to construction technology	Efficiency					Selection criteria (Success/ benefit related factors)				
		1	**2**	**3**	**4**	**5**	201	202	203	204	205
301	**Earth Work**										
301(A)	Spider excavators (used in every terrain)										
301(B)	Mini excavators (for tight and confined areas)										
301(C)	Articulated hauler (to transport loads over rough terrain)										
301(D)	Tunnel boring machine(TBM)										
302	**Floors Walls and Slabs**										
302(A)	Pre-fabricated and assembly system										
302(B)	Pre-cast system (Manufactured off- site)										
302(C)	Bubble Deck slab flooring (used to reduce the weight of the slab for multi-story building)										
302(D)	EzyProfile-slab profiling tool (for easy slab set up reusable tool)										
302(E)	Self-cleaning glass windows										
303	**Temporary structures (Formworks)**										
303(A)	Steel panel modular formwork (used on large projects /reuses of the shuttering is possible)										
303(B)	Aluminum formwork system (used for both high rise and low rise buildings)										
303(C)	Plastic formwork systems (easy transportation and speedy assembly of										

	components reusable)										
303(D)	Movable formwork										
304	**Reinforcement**										
304(A)	Mesh bending and cutting machine										
304(B)	Mesh welding machine										
304(C)	Shaping centers										
304(D)	Reinforcement bar coupler										
304(E)	Automatic rebar tying machine										
305	**Concrete works**										
305(A)	Concrete pumps (machine to transfer liquid concrete boom pumps and line pump)										
305(B)	Cast- in- place Booms (stationary placement booms)										
305(C)	FRC (Fiber reinforced concrete)										
305(D)	Admixture chemicals (accelerator, retarder, water reducer)										
305(E)	Automatic Concrete screening machine										
306	**Block masonry**										
306(A)	Movable/stationary block making machine										
306(B)	Mobile mortar mixer with a Tele- handler										
307	**Finishing Works**										
307(A)	Plastering machine (capable to render on bricks and concrete blocks)										
307(B)	Glass Tiles (manufactured piece of hard-wearing glass used for floors, walls, showers)										
307(C)	Airless spray painting machine										
308	**Water proofing materials**										
308(A)	Masonry water proofer (controls water migration through concrete masonry and brick walls)										

308(B)	Damp proofing cream (DPC) (waterproof layer applied into base wall)										
309	**Information and communication technology**										
309(A)	3D hand held computers(able to scan spaces/ rooms for placement of pipes)										
309(B)	3D printing (making three dimensional sold objects from a digital model)										
309(C)	Building Information Modeling(BIM)										
09(D)	Ground Penetrating Radar (GPR) systems for civil works										
309(E)	Spectra precision laser Scanning										
309(F)	e-business technology (for procurement)										
310	**Delivery system**										
310(A)	DB(Design build) Related Delivery system										
310(A1)	Pure DB										
310(A2)	Enhanced /novated/bridge DB										
310(A3)	Turnkey DB										
310(B)	CM(construction management) Related Delivery system										
310(B1)	CM as Agent/ free										
310(B2)	CM at Risk										
310(B3)	CM Prime contracting										
310(C)	PPP (Public private Partnership) Related Delivery system										
310(C1)	BOT related PPP										
310(C2)	PBC related PPP										
If others Please specify and rank											

Section 4: Construction technology transfer model compensable

Rank the effectiveness of each factor for construction technology transfer. If you need additional information about the popular construction technology transfer model refer the preface on page 2

Code	Construction technology transfer model related factors	1	2	3	4	5
401	Needs Assessment and Technology Assessment(Mulder and Kassahun Yimer)					
402	TT Life Cycle based intra-firm Model (Malik)					
403	Comparative Marketing TT Model (Clantone et al)					
404	Technology Acquisition / Process Model (Simkoko)					
405	Source to Destination Movement based CTT model (Wang et al)					
406	Transferor ←→ Transferee for Technology Transfer Model (Lin & Berg TT)					
407	Value Added TT Model (Wrookun)					
408	Human Centric /Dual TT Model (Al-Khazarji)					
409	Transferee Driven Technology Transfer Model (Wubishet Jekale)					
If others please specify and rank						

Section 5: Technology transfer process:

These are the stages on which transferee and transferor should follows for the transfer of technology. Please rate your opinion (1, 2, 3, 4, 5)

Code	CTT transfer process related Factors	1	2	3	4	5
501	Need assessment (problem identification)					
502	Construction technology transferee selection					
503	Construction technology transferee demand determination					
504	Construction technology priority determination					
505	Construction technology partner selection					
506	Construction modes selection					
507	Construction technology transfer testing/piloting					
508	Construction technology transfer implementation					
509	Construction technology outcome determination					
If others please specify and rank						

Section 6: The construction technology transfer channels:

Channel is the link between two or more social entities in which various technology transfer mechanisms can be activated. Please rank your opinion based on the applicably of the channel for the Ethiopian construction work (1, 2, 3, 4, 5).

Code	**CTT Channels related Factors**	**1**	**2**	**3**	**4**	**5**
601	Foreign Subsidiary (FDI)					
602	Joint Ventures					
603	Foreign Minority Holding					
604	Fading Out Agreements / Direct Purchase of Capital Goods					
605	Licensing, Franchising, Patents, Trade Mark, Branding Agreements					
606	Management, Turnkey, and Sub Contracts					
607	Training					
608	Import Substitution					
609	Imitations (Reverse Engineering)					
610	Best / Proven Practices					
611	University ←→ Industry Linkages					
If others please specify and rank						

Section 7: Construction technology transfer conducive environment

Conducive environment for technology transfer includes Transferee characteristics, transferor characteristics, relationship building and transfer environment. Rank the effectiveness of each factor for construction technology.

Code	Conducive environment related factors	1	2	3	4	5
701	**Transferee Characteristics**					
701A	Transferee readiness					
701B	Knowledge base					
701C	Transferee management practice					
701D	Transferee degree of experience					
702	**Transferor Characteristics**					
702A	Transferor willingness					
702B	Knowledge base					
702C	Transferor management practice					
702D	Transferor degree of experience					
703	**Relationship Building/Learning Environment**					
703A	Culture difference between transferee and transferor					
703B	Trust between transferee and transferor					
703C	Understanding between transferee and transferor					
703D	Communication between transferee and transferor					
704	**Transfer Environment**					
704A	Economic level of the country					
704B	Government enforcement of technology transfer (TT)(rules and regulations)					
704C	Clear Government Policy (Science and technology policy)					
704D	Mode of transfer (Joint Venture, foreign direct investment (FDI), turnkey etc)					
704E	Technology complexity					
704F	Physical infrastructure (road, water, electricity)					

704G	Finance, information, skill development and technology brokering (Supportive institution)					
704H	Mechanism for intellectual property right					
704I	Tax holidays, tariff adjustments and industry parks related Legislation and incentives					
704J	Implementing efficiency at various level of government (Bureaucracy)					
704K	Tax Policy effectiveness					
704L	Foreign currency stability					
If others please specify and rank						

Interview Questions for Case study

1. On which technology transfer program you involved in?
    - University capacity building program (UCBP)
    - Industry park
    - Working with foreign contractors
    - If others please specify
2. What are the motivations/selection criteria are used for the technology transfer?
3. What type of construction technologies are practiced in your organization for the last 10 years?
4. Could you tell me how did you transfer it/which channel did you use/to transfer the technology in to your organization?
5. What kinds of conducive environments have you created for the technology transfer? (Transferee characteristics)
6. Could you tell me about the relationship between your company and the transferor?
7. What is the improvement in your organization after the technology transfer?
8. What are the best practices you gain from technology transfer program (UCBP, Industry parks, working with foreign contractors, etc.)?
    - tools
    - Technique
9. If there is anything not mentioned in the above please specify?

QUESTIONS

For key informant interview

Section 1: Existing technology practice

101. What are construction technology transfer practice in Ethiopian construction industry? Pleas list them

102. What are the strength/ enablers in the existing CTT practices you participate in? Please specify

103. What are the gaps/ problems faced in the existing CTT? Pease specify

1. Technology Transfer Process Issues
   - During the technology justification and selection stage
   - During the planning stage
   - During negotiations stage
   - During Trial/Piloting stage
   - During implementation/Adoption stage
2. Corporate/organizational Capability Issues
3. Operating Environment/Transferor and transferee /Issues
   - i. Transferee Environment
   - ii. Transferor Environment
   - iii. Learning Environment
4. Any other? Please

104. Which kind of construction technology transfer method/ channel is used? List them

Section 2: Technology transfer mode

201. What type of technology are practice and need to be practice in Ethiopia Construction industry? List and give reason

202. Which technology transfer method/channel is appropriate for the Ethiopian construction work? Please specify and why?

Section 3: Outcomes of Construction Technology Transfer

301. Conserving with the contribution of technology transfer in the value creation for the Ethiopian construction sector please specify the advantages

a) Economic advancement
b) Knowledge advancement
c) Project performance

302. How to improve construction technology transfer for the Ethiopian construction industry?

Appendix B

Case study

Technology cannot be measured in quantitative terms, as it is an intangible asset. Therefore, a ‘qualitative assessment' method has been used in this study. A Qualitative assessment is a subjective study with no statistical analysis. In a qualitative assessment process, the data gathering is in a natural setting such as observation, in-depth interviewing and use of records or other materials. The result of this type of assessment is mainly in the form of narrative. Since the research questions were defined as exploratory statements, an exploratory type of case study was adopted in this study. An embedded case study design, having interviews, discussions and observations as the method of analysis was selected. The target group was selected based on their experience and the knowledge they had on the technology that have been transferred to their organization.

In each case the questions were focused on the familiarization in terms of the components of the technology and the technological capabilities. Under the technology the strength of each organization in terms earth work, floors, walls, slabs, formworks, Reinforcement, concrete works, block masonry, finishing works, information and communication technology and project delivery system. Relationship between transferor and transferee was surveyed based on the learning mechanism adopted in the organizations. It includes learning by doing, crude copying, adaptive copying, training, hiring foreign management, and searching new techniques. The technology transfer methods/channel the elements considered under this section is availability of drawings, specification, material list, operating manuals and computerized information systems. Conducive environment focused on the adequacy of the organization structure in terms of technology transfer aspects. The improvement achieved from the technology transfer on the organization. The best practices the organization gain from technology transfer program tools and techniques. The companies participating in the case study are Aser construction, Afrotsion construction, Flintstone construction and MH engineering and consulting plc. A brief introduction to each case and the summary of the results are presented in this section.

Case study one

The organization in this case, started its operations in 2009 in the fields of Grade 1 water works General contractors (WC-1). This company was granted license for grade 1 General contractor (GC-1) in 2012 to perform all construction duties including road and building works. It participates in the technology transfer programs of Industry parks and working with foreign contractors. In this program the method/channel of technology transfer was Subcontracting, Joint venture, training and direct purchase of capital goods are practiced. The company is operating a fully art of engineering construction materials manufacturing plants of concrete batching , crusher plant, concrete pipe and asphalt plants; all of which are automated and run by experienced professionals, in addition to owning sufficient both heavy and light equipment and machinery.

The company has now managed to expand even more by installing two modern and fully computerized 120 meter cube per hour concrete batching plants starting from a year 2015. The quality of material used for the ready mix concrete such as cement, sand, aggregate and admixture are tested and confirmed in line with the best quality control and quality assurance system. This construction company provides concrete casting using concrete boom pump in addition to delivering ready concrete mixes on trucks.

The company has installed a Marini asphalt plant, dedicated to the production of different grade and type of asphalt products. The plant is fully commissioned with the capacity of producing 90-120 ton asphalt per hour. The new comprehensive asphalt mixing plant has its own certified materials testing/quality control laboratories.

This construction company has installed the concrete piping pant, dedicated to manufacture reinforced concrete pipe (RCP) products for underground utilities and road building industry. The concrete pipe products are customized for application including storm drain, sewerage, and waste water disposal from factory, manholes and others. The plant has an average capacity of producing 25 different sizes of pipes per day. The concrete pipe plant produces a comprehensive line of RCP with varying length and diameters of 600mm, 750mm, 900mm, and 120mm diameters of concrete pipes. It has used steam technology for the concrete pipes to attain its expected compressive strength within 2-3 hours.

This company has installed crushing plant produces and supplies wide range of aggregate materials to the construction sector with the capacity of producing 150 tons per hour. It provides different types of aggregates used for concrete, base course, sub base and asphalt.

The company transfers a technology of construction management techniques from foreign contractors. Uses a working on night during road construction is a better time management instated of day time in managing traffic flow and working fast for the dump trucks (15 trips during night time and 4 trips a day time). It also develops ICT based communication within or out of the company to communicate and recording.

Case study Two

This company was participated in UCBP program. During the time of participation it has a licenses from ministry of construction as BC3, which expected to work building construction under category three. Immediately after the program the company upgraded into BC1 licenses which is the first category of building constructors. After a while This Company was granted license for grade 1 General contractor (GC-1) to perform all construction duties including road and building works. Gating construction services the can satisfy the requirement of the client related statutory and regulatory requirements of ISO 9001:2008

It participates in the technology transfer programs of University capacity building program and working with foreign contractors. In this program the method/channel of technology transfer was Subcontracting (Addis Adama road project), Joint venture, training (on job training, preparation of manual, project management), Import Substitution (production of aluminum profile) and direct purchase of capital goods are practiced (bar cutting and bending machine, plastering machine, painting machine, concrete and asphalt plant, brick production factory and different equipment). The company is operating a fully art of engineering construction materials manufacturing plants of concrete batching plant, asphalt Batching Plant, Block and brick manufacturing, and Aluminum profile manufacturing; all of which are automated and run by experienced and trained professionals, in addition to owning sufficient both heavy and light equipment and machinery. The company is now exciting the construction of airport runways that meet international and local standards, taking major constructions in Building.

The company owns new technologies and apply in variety of works some of them are listed below: Primarily in the concrete work mobile mixer for mortar and concrete, concrete plant, concrete pump, and asphalt plant. Secondly in the reinforcement work the company owns bar cutting and bending machine and it increases the quality, the productivity time completion, minimize waste.in the third place the block work it manufacture brick, block and aluminum frame and increase and maintain the quality and productivity. Fourthly in the finishing work using plastering machine and painting machine develop timely completion, improved quality and minimize waste of material. On the water proofing technology the membrane and cementitious material are used it increase the qualities of work. Lastly the delivery system practiced in the company was basically DBB but it starts to participate in DB not less than four projects from this it gain new knowledge in performing the complete work of the project.

The improvements in the organization after the involvement of technology transfer are

- Technical training on strategic planning and financial management that improve organizational effectiveness.
- Increase the ability to perform core functions, solve problems, define and achieve objectives and setting organizational Vision and Mission
- Develop management capacity in effective and efficient use of organizational management of Human resource, financial management, technical management and adoptive capacity of new techniques.
- Track record improvements to bid for more project and improve competitiveness in the market.
- Organizational sustainability that perform set of activities as a process that accomplish a specific goal

For the effective technology transfer the top management and owner of the company commitment is more valuable. The company now diversified itself in to sister companies in construction material import and distribution plc, Bricks Products Processing S.C., real Estate construction, coffee production, resort and spa.

Case study Three

The organization in this case, started its operations in 1991 as a small construction firms. This company was granted license for grade 1 Building contractor (BC-1) to perform all construction duties in building works.

This company was participating in university capacity building technology transfer program and Africa Union building projects. The method/ channel of technology transfer practiced in the company were subcontracting (Au project), Import substitution (formwork, I beams with RHS), direct purchase of capital goods (plastering machine, batching plant, machinery) and training (from UCBP, on job skill training, Knowledge, technology and method of construction).

From UCBP program the company adopts technologies in the field of project management, planning, claim resolution and handling, develop skill in carpentry and gating continuous improving on quality management system of ISO 9001:2000 certifications. On the other hand when the company participating in the African union building project the new technologies transfer are construction methods, installed concrete batching plant, formwork system(waffle formwork system) for slabs column and wall concrete, earthwork technologies like shoring (temporary structure), shit pill; use of prefabricated materials such as stair case, slab; finishing works materials and equipment like plastering machine; leveling instrument like laser surveying; information communication technologies like building information modeling (BIM); advanced skill in the sanitary and electrical works; practicing alternative delivery systems like Design build contracts. After the technology transfer the company is improved in strategical planning, Project management, financial management, contractual management and increase organizational competitiveness and sustainability.

Case study Four

The company was established in 1997 with the primary objective of providing multidisciplinary consulting service to the public as well as private firms engaging in the development of various type of economic and social infrastructure and buildings. The company has international experiences in participating in the following technology transfer program and projects

- design of real estate development D.R. Congo,
- Design of Pakistan earthquake reconstruction with GTZ/LCH,
- Design of EEPCO,s head office building with Ove ARUP, UK
- Design and construction supervision of the New Netherland embassy in association Ove Arup and architects group, Netherlands
- Construction supervision of Butajira Hosahna road project in association with DHV,Netherlands
- Construction supervision for the construction of shelter for the Lalibela church with Teprini Associate, Italy
- Design and construction supervision of the new South Africa embassy in association with Steware Scott international and MMA Architects, South Africa
- Design and consultancy service in UCBP program (responsible for the master plan, building and infrastructure network design of the university campus, Sewage water systems, Water supply systems, Electrical power supply, and Sewage water treatment plants that will be beneficial for the entire country).
- Design reviewer and construction management for Industry park construction (gaining new knowledge about industry park design and construction, new method of design in medium voltage design of electric lighting design , in a sanitary department learn design and recommending energy saving and water saving materials, in the architectural design, use of culculex software for lighting calculation. In the architecture department the company gain new knowledge in detailing design during design review.

In general after the technology transfer the company develop new organizational structure. In the year 2007 departments of architecture, structure, sanitary, Electrical, contract administration and other formed with duties and responsibilities. The best practice gain from the transfer are new knowledge in software construction material contract administration and knowing and practicing international and local standards, forecasting (risk registration and mitigation), check list and follow up reports, developing the lesson learned from each project is recorded both bad and good to keep the technology transfer in the company. After participating in the industry park project the company the company coping the design technology and complete a full design of other industry parks of Yirgalem and Bulbula. Now it is the first competent design and consultant company in stadium, Industry Park, building and road projects.

Appendix C

Key informant interview

The participants for the key informant interview are professionals from UCBP program and MoC. The respondents acknowledge that were a little technology transfer practice and most of them are unorganized, unplanned and practiced by government influence. The participants listed the existing technology transfer for the Ethiopian construction work

1. The well-known technology transfer practices in the construction sector was the UCBP program.
2. Conferences and workshops which are focused on the new technology to increase the productivities of the construction sectors.
3. Different trainings about worldwide construction technologies

The strength of the technology transfer practice for the construction work in the UCBP professionals from different construction companies were participated and gate trained both theoretical and on job technical works. This gives a clues for the emergence of many consulting companies and fulfilling international standards (ISO) certification, developing managerial skill, organizational structure for the companies, develop the financial capacity for the organization to be competent locally and some companies upgrade the companies into higher level etc. furthermore the respondent acknowledged that the outcome determination of the technology transfer is a vital for determining the success of the technology transfer.

According to the respondents the problems faced during construction technology transfer process are the level of reediness to accept the worldwide technology, the language difference on both sender and receiver, the level of experience on the technology, the knowledge level of the transferor were observed.

The respondent also identifies the technologies that facilitates the productivity of the construction company. Based on the participant the channels appropriate for the Ethiopian construction work are training, Joint venture, sub-contracting form foreign companies, porches of capital goods and foreign direct investment (FDI) are selected by the respondent.

The conducive environment for the technology transfer should be assessed based on receiver, sender and the government. Each stockholders should tech focused for the effective transfer of the technology in to domestic companies and local professionals

Appendix D

Existing Construction Technology Transfer practice in Ethiopia

1. University Capacity Building Program (UCBP)

According to (www.ucbp-ethiopia.com, accessed in 2018) the University Capacity Building Program (UCBP) is a large-scale capacity development and construction program initiated and funded by the Ethiopian Ministry of Education (MoE) and Ministry of Capacity Building (MoCB).The Government of Ethiopia has declared capacity development one of its main objectives. It formalized this commitment in 2001, when the MoCB was established. Their efforts are particularly demonstrated in large projects such as the UCBP, which uses experiences from the German construction sector as benchmarks.

As the project management and implementation agent, GTZ International Services' foremost task is to develop the capacity of the Ethiopian construction sector. GTZ supervises the construction of 13 universities at 15 different sites throughout Ethiopia, mostly in rural locations. A phased approach to building has allowed students to already begin classes at UCBP campuses in early 2007.

In UCBP, MH Engineering is responsible for the master plan, building and infrastructure network design of the university campus. GTZ IS coordinates every step of this process- from the definition of room programs with regard to client demands to the final design for all trades.

The UCBP constructs 13 universities (Axum, Dessie, Kombolch, Debre Markos,Debre Birhan, Adama, Nekemt,Sodo, Dilla, Tepi and Mizan Teferi, Robe, Semera, Dire Dawa, Jijiga) in 15 locations throughout Ethiopia on 1,500.000 square meters for 121.000 students. The aim of the program was first to modernize Ethiopia's construction sector, leading to increased international competitiveness; second Design and construct public universities in 15 locations throughout Ethiopia, at a competitive cost and in a short time span.

The capacity development at all levels of intervention supports companies to reach international standards in quality, safety, efficiency and modern technologies. Knowledge is transferred through management trainings and workshops such as change management, financial management, equipment management, and marketing. It supports involved companies in implementing the quality management system ISO 9001:2000.

Onsite, UCBP conducts practical on-the-job trainings. German and national master craftsmen upgrade the skills of construction site workers in major trades, such as masonry, carpentry, metal- and woodwork, plumbing and electricity. Theoretical sessions, such as mathematics, physics and engineering, reinforce these hands-on trainings.

One fundamental element of the planning processes in UCBP is to apply and improve the Cost Efficient Design (CED) methodology which allows the implementation of pre-fabricated and standardized elements. This saves money by reducing both construction time and material wastage, allows a rapid construction without compromising quality, and streamlines established principles in construction efficiency.

Infrastructural solutions allow a sustainable integration of: Sewage water systems, Water supply systems, Electrical power supply, and Sewage water treatment plants that will be beneficial for the entire country.

UCBP encourages the formation of local enterprises and strengthens already existing ones through: enabling the contractors to subcontract up to 40% of construction works to local enterprises, providing entrepreneurial and managerial trainings for business sustainability, conducting practical trainings on-the-job to upgrade the skills of workers in trades such as masonry, metal works, carpentry, electricity and plumbing, cooperating with local “Technical and Vocational Education and Training-TVET” colleges, offering internship to their students and “Start-up business” workshops to graduates who are interested in creating their own construction related enterprise.

2. Industry Park

According to (http://ipdc.360ground.com, accessed in 2018) to realize the ambitious development plan of the country aiming to rapid industrialization nurturing manufacturing and agro-processing industries, to accelerate economic transformation and attract domestic and foreign direct investment, the Ethiopian government came up with the decision to develop industrial parks providing the necessary services and facilities for industries. Two kinds of industrial parks are being developed: large, medium and light scale industrial parks on the one hand, integrated agro-industrial parks on the other hand.

In order to ensure a proper management of the industrial parks, the Ethiopian Government came up with the Industrial Parks proclamation 886/2015 providing that industrial parks can be developed by any profit-making public, public-private or private enterprise. This includes the Industrial Parks Development Corporation (IPDC), which is in charge of managing the development of large, medium and light industrial parks and the ministries of industry and agriculture, which are responsible for the integrated agro-industrial parks development. The investment is open to national, domestic and foreign investors. The industrial parks developers are entitled to develop their own industrial parks, either independently or through public-private partnership with IPDC. With regard to large, medium and light industrial parks, IPDC is mandated as a facilitator of land bank and main infrastructure provider for private industrial park developers.

China Civil Engineering Construction Corporation (CCECC) completed the Hawassa Industrial Park within nine months. It took five years for 23 local contractors just to complete the first phase of Bole-Lemi Industrial Park. While particularly in large projects that need timely and quality delivery, with local contractors, following the poor performance they need to take a lesson to transfer the technology from foreign contractors (Samson Berhane, 2016).

According to the Ethiopia second Growth and Transformation Plan (GTPII).The government is currently adopting an FDI led industrialization, aiming to catalyze technological transfer. Increasing the skilled manpower, providing assistance to small and medium enterprises, supporting research and training, and encouraging start-ups and innovations are all strategies adopted by the government to attain the technology transfer,

3. **The federal democratic republic of Ethiopia science, technology and innovation policy (STI)**

It is important to create a national framework that will define and support how Ethiopia will in future search for, select, adapt, and utilize appropriate and effective foreign technologies as well as addressing the establishment of national innovation system.in order to facilitate the technology transfer ministry of science and technology develop a policy having the following vision, mission and strategies on technology transfer and development.

The national capability to learn, adapt and utilize foreign technology is still at a very low stage. Therefore support will be given to create capabilities which enable to search, select, adapt, and utilize effective foreign technologies that support development needs. STI develop strategies for the technology transfer

Technology Transfer Strategy

- Import effective and appropriate foreign technologies and create capabilities of adaptation and utilization of these technologies in manufacturing and service providing enterprises;
- A system to search, select, adapt, utilize as well as dispose imported technologies should be established and implemented;
- Establish and implement a system to use foreign direct investment (FDI) and other ways of supporting technology transfer;
- Strengthen technology transfer among and between various manufacturing and service providing enterprises;
- Strengthen wide use of intellectual propriety, standards and other related information in support of technology transfer.

4. Second Growth and Transformation Plan GTPII

The second Growth and Transformation Plan (2015/16-2019/20) is considered to be an important vehicle for Ethiopia's renaissance. Under Science and technology development category the plan focuses:

High human capital formation and technology transfer

- Established research funds to enhance national technological capability
- Established research institutes
- Increased number of eligible radiation and nuclear technology regulator institutes

Increase number human capital in science and technology

- Increased number of researchers in fields of natural science, engineering, medicine, and agriculture
- Increased number of PH.D holders at Adama and Addis Ababa Science and Technology Universities
- Increased number of graduates from Adama and Addis Ababa Science and technology Universities

Appendix E

Output of analysis

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Conducive environment , Popular model, New technology, Transfer process, Channel[b]	.	Enter

a. Dependent Variable: Selection Criteria
b. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	6.524	5	1.305	2.345	.0058[b]
	Residual	23.375	42	.557		
	Total	29.899	47			

a. Dependent Variable: Selection Criteria
b. Predictors: (Constant), Conducive environment , Popular model, New technology, Transfer process, Channel

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.467[a]	.218	.125	.74602

a. Predictors: (Constant), Conducive environment , Popular model, New technology, Transfer process, Channel
b. Dependent Variable: Selection Criteria

Coefficients[a]

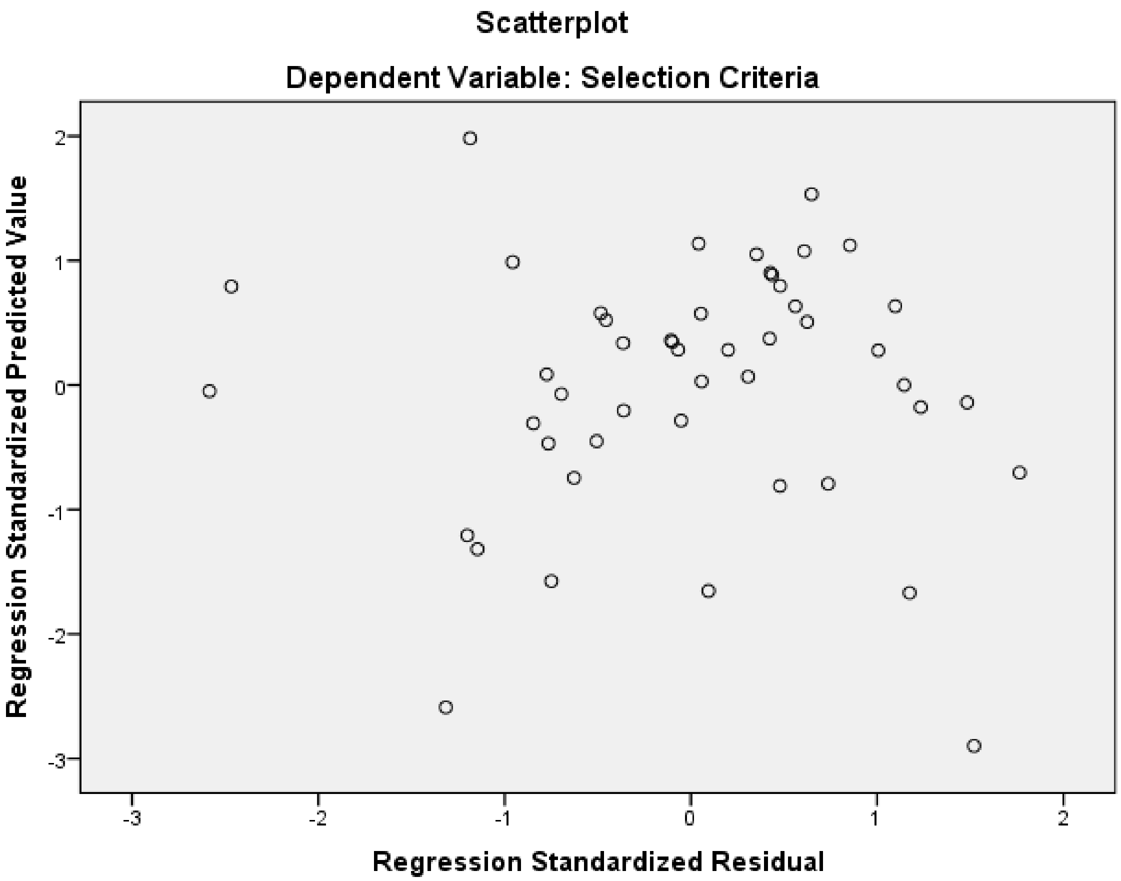
Model		Collinearity Statistics Tolerance	VIF
1	(Constant)		
	New technology	.652	1.535
	Popular model	.778	1.286
	Transfer process	.501	1.997
	Channel	.401	2.496
	Conducive environment	.247	4.051

a. Dependent Variable: Selection Criteria

Collinearity Diagnostics[a]

				Variance Proportions					
Model	Dimension	Eigenvalue	Condition Index	(Constant)	New technology	Popular model	Transfer process	Channel	Conducive environment
1	1	5.891	1.000	.00	.00	.00	.00	.00	.00
	2	.043	11.673	.06	.02	.16	.02	.20	.02
	3	.025	15.317	.05	.83	.08	.06	.01	.00
	4	.019	17.387	.14	.00	.00	.64	.28	.00
	5	.014	20.571	.54	.02	.54	.14	.01	.10
	6	.007	29.269	.22	.13	.23	.14	.50	.88

a. Dependent Variable: Selection Criteria


Scatterplot
Dependent Variable: Selection Criteria
Regression Standardized Predicted Value
2
1
0
-1
-2
-3
-3
-2
-1
0
1
2
Regression Standardized Residual